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The Welsh Engineers' and Founders' Association
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Contents

	PAGE
Exporting Foundry Products	197
Price Levelling	198
Progress in Tin Research	198
Publications Received	198
Random Shots	198
Sand Testing with Special Reference to Deformation	199
Thicknessing Methods	202
Copper in Cast Iron	203
Catalogues Received	204
Cast Iron and its Relation to Machine Tools	205
Electrolytic Preparation of Micro-Specimens	207
Book Review	207
Ironfoundry Practice, 1919-1939	208
Cylinder Wear	210
Heavy Nickel Plating	210
The Week's News in Brief	212
Trade Talk	212
Personal	212
Obituary	212
Contracts Open	212
New Companies	212
Applications for Trade Marks	212
Reports and Dividends	212
Forthcoming Events	212
Raw Material Markets	214
Stimulating Export Trade	214

Exporting Foundry Products

For some time now the Export Council constituted by the President of the Board of Trade has been at work devising means for a large expansion of overseas trade made necessary by the exigencies of war, and the Government have approved for publication a statement setting out its aims and plans. It took the form of a White Paper issued last week, and states that the duty of the Council "is to ensure that every agency, whether Government Department, manufacturer or exporter, makes every effort to attain this objective, and they will recommend any measure which they find necessary or desirable." Reasons are put forward for achieving these ends by utilising existing channels with the least disturbance to established practices and customs, but no measure is to be excluded from consideration. Naturally enough, the Government have to take into consideration in what parts of the world credit is most needed.

The statement stresses that "It is essential that under war conditions, exporters should receive direction, guidance and support from the central Government to a degree never contemplated under peace conditions. If export trades, including both manufacturers and merchants, are organised or will organise themselves so as to make it possible for them to work with the Export Council in securing the necessary adjustments in the wartime machinery of trade, and so as to profit effectively from the direction, guidance and support which the Government are ready to give, the general situation, internally and externally, is such that the Council are confident that a substantial increase of exports can be achieved."

It is thus made perfectly plain that individual firms within the foundry industry having excess manufacturing capacity should, through their employers' federation, either the British Ironfounders' Association, the Ironfounders' National Committee or other similar body, make this fact known. At the same time, they should apprise these authorities of any export inquiries they have received. Within these authorities there will be formed an export committee or group, and in this connection it is pointed out that the collaboration of export merchants in the work of the groups is most important.

The various types of foundries should ascertain for themselves whether their particular trade organisation has made contact with the executive members of the Export Council. This action is urgent as it is authoritatively announced that already some industries have completed their machinery and discussions are already taking place. War exigencies apart, it is reasonably safe to assume that the outcome will be "first come first served." Naturally, the attached foundries will have to rely on the efforts made by their administration through the particular type of industry catered for, but if an excess capacity be available, the foundry manager would be well advised to bring this fact before his managing director as a potential for increased activity.

As the export trade often differs materially from home requirements, founders would be wise to approach the foreign commercial attachés (or get their employers' federation to act for them) for details of those designs of hardware, sanitary ware, cooking utensils and so forth most popular in the various countries. The Scandinavian countries, generally speaking, require material suitable for use in connection with electric power, whilst other groups of countries still largely rely on wood as their fuel. Much information as to the requirements of overseas markets must exist in the files of the Government Department covering that activity. In any case, the Reports prepared by the various commercial counsellors are worth consulting. This sort of information can be and should be gleaned by the individual firm, as the actual booking of orders is a matter for each concern and factors of competition will still operate; it is expressly stated that the Government will not undertake any representation in overseas markets.

We are profoundly ignorant of the intricacies of shipping, but we are aware that pig-iron is often bought for ballast. As textiles form a large part of British exports, it may be that a modicum of cast-iron ware would help to balance the load, in much the same way that sand has been used in the wool boats arriving from New Zealand.

Price Levelling

By "Onlooker."

That prices find their own levels in line with supply and demand is an economic truth which time and use have worn nearly threadbare, but like a good many more obvious facts it is apt to be obscured by a number of things most of which are probably of a temporary nature. Given a free market, with none of those complications which arise from the operation of foreign exchange, tariffs, controlled production and the like, one can doubtless see this economic axiom functioning according to plan, but in these days (and not only since the war) how many markets can claim that they are carrying on without let or hindrance?

There are, of course, a number of ways in which prices may be fixed. Monopoly enables a producer to hold the consumer to ransom if his ideas run that way, while the dead opposite of that condition of affairs is the producers' price war resulting in starvation returns on a big output and happy days for the user. There may be groups of middle men powerful enough to see to it that neither producer nor consumer has a very good time, and finally there may exist a market such as normally functions in Whittington Avenue, where all who wish may buy and sell without restriction. Such a system of trading would certainly seem to approach most nearly to a real scheme of price levelling.

The Case of Copper

In the ordinary course of events there is an endless process of price adjustments in metals, subject of course to the existence of tariffs which may distort values in certain centres of trading. In copper it will be found that although the United States has a 4 cent import duty on this metal, and while the price in the domestic market does almost invariably rule above the parity of the sterling quotation, yet in normal times offers for export come at a figure which is directly competitive with the London wirebar price. America is keenly interested in the European market, and since this centre of trading normally takes as its price indicator the London market, it follows that U.S. exporters of copper must fall into line.

Consideration has also to be given to the large production from the Chilean properties owned by American companies, for this copper is barred out of the United States through the operation of the duty barrier. Zinc and lead are also very adequately protected in the States, and here we find that the parity rules always well above the quotations in London. It is many a long year since American brands of lead and spelter have been seen in the United Kingdom, and there does not seem to be any likelihood of their coming again.

In fixing the maximum prices at which trading in non-ferrous metals would be permitted, the Ministry of Supply had to give due thought to this all-important question of levels, but it was made quite evident that the Empire was going to make its own arrangements for supplies when the actual figures were published. There was in fact a wide disparity between our values and what might be expected elsewhere, but it was on the right side from the British taxpayer's point of view. The upward adjustment in December lessened this difference, but it remains nevertheless, and there is every prospect that consumers in the United Kingdom will continue to obtain supplies at several pounds per ton below the cost in the United States. Yet another example of vagary in price levels, but one which brings great benefits during this period of wartime consumption.

Progress in Tin Research

A new type of electroplating suitable for motor-cars, refrigerators and so on, is mentioned in the 1939 Report of the International Tin Research and Development Council, issued last week. The coating consists of tin and copper in the proportions in which these metals are combined in speculum metal, of which the brilliant reflective qualities have for centuries been utilised for hand mirrors and, in later times, for telescope mirrors. The new application follows upon the success of research work on the simultaneous electro-deposition of tin and copper in these proportions. This speculum plating is hard, has a pleasing silver colour and high resistance to corrosion and is expected to compete favourably with chromium.

Early in the year under review the building of the Council's new offices and laboratories at Greenford, Middlesex, was completed and the equipping of the laboratories has been proceeding. Since the outbreak of war research has been concentrated upon tinplate, bearing metals and tin coatings on steel and copper. Devices for producing a better quality of tinplate are being tried and a process for producing a passive surface on this material has been found and is being thoroughly tested with canned foods; the results are so far very encouraging.

Many years of research have now enabled the Council to issue precise directions for the successful electro-deposition of pure tin in any desired thickness upon other metals. This process is being taken up by makers of food-manufacturing equipment, as these thicker coatings will give a correspondingly longer life than the hot-dipped coatings hitherto in use without a material increase in cost.

Exceptionally strong tin alloys are another development, and three of the new alloys are now undergoing tests as bearing metals for internal-combustion engines. Among other new alloys are improved types of pewter having enhanced resistance to wear and corrosion, and it is expected that the unfortunate sagging that sometimes afflicts pewter teapots will become a thing of the past.

Trials are continuing with a new class of bronzes richer in tin than has before been practicable.

Publications Received

Monthly and Yearly Highest and Lowest Prices. Published by Fredc. C. Mathieson & Sons, 16, Copthall Avenue, London, E.C.2. Price 2s. 6d.

The prices referred to in the title are those of selected active stocks dealt with on the London Exchange marked monthly for twelve months to the end of December, 1939, and yearly for the past six years.

Survey of the Import Trade of India from April 1 to September 30, 1939. Prepared by H.M. Senior Trade Commissioner in India, Burma and Ceylon. Published by the Department of Overseas Trade, Great George Street, London, S.W.1.

The outstanding feature of the Indian import trade during the period under review was the striking increase of the trade done with Burma. This factor decreased the percentage of trade done with other countries very materially. In terms of value, the United Kingdom and Italy showed some decrease, whilst Germany, Japan and the U.S.A. registered gains. Of purely cast-iron products, pipes and fittings, the total imports were 1,720 tons valued at Rs. 4.9 lakhs, of which the United Kingdom supplied 1,664 tons valued at Rs. 4.7 lakhs. The total imports in 1938 were 1,453 tons, and imports from the United Kingdom 1,379 tons. This position is extremely satisfactory, for even the 56 tons may not represent actual pipe, but more likely refers to fittings.

Random Shots

One of the great questions of the day is whether haggis will become a prime favourite on the English table, now that meat rationing has started. Its contents have ever been a matter for much derogatory speculation on this side of the Border, but if it is really made of the ingredients accorded to it by one authority, who swears that it is "cat's meat done up with dog's meat and the whole boiled in a bagpipe," then it should become a convenient dish for days when the meat ration is exhausted.

* * *

By the way, let it be put on record, whilst meat rationing is still in its infancy, that the shortage of cats in the Metropolis has been acute for some months. "Marksman" prefers to think that this is a direct result of early A.R.P. measures, and has nothing whatsoever to do with the manufacture of haggis, sausages, or even polonies.

* * *

That there is no need for anyone to make a song and dance about the rationing of any foodstuff is amply demonstrated by the notice at present displayed in a local grocer's shop: "We stock 1,500 lines, of which only 3 are rationed."

* * *

"German aeroplanes have not yet flown over London" states an official denial of a rumour. No; but the German measles has penetrated a few provincial schools this spring.

* * *

A little girl who lives in one of the Government's new evacuation areas came home from school the other day and told her mother that it has just Dorniered on her about this Heinkel business, and therefore she'd evacuate herself to an aunt who lives in the West Country.

* * *

It is hard that thousands of men who fought in the last war are having to send sons to join the forces in this one; but perhaps they will glean a grain of comfort in two bits of philosophy taken from "The Far Eastern Review":

"If a boy could profit by the experience of his father he would die of inertia."

"It is strange that men who learn from the Book of Experience try to hide that volume from their sons. Experience is as necessary for the son as it was for the father."

* * *

The following story appearing in the "111 Magazine" is told against an Irish provincial railway, but English business men will probably delight in adapting it to suit some particular wartime journey into the provinces. It goes like this:

Important passenger to guard: "Can you not go any faster?"

Guard: "I could, ma'am, but I must stop with the train."

* * *

Here is a grim warning from the same publication:

"Mary had a little lamp,
She filled it with benzine;
She went to light her little lamp
And hasn't since benzine."

"Marksman."

Sulphur in Cast Iron

The new issue of "Foseco News," the house organ of Foundry Services, Limited, 285, Long Acre, Nechells, Birmingham, 7, contains a very useful article on "Sulphur in Cast Iron"; it outlines four possible methods for its reduction: (1) Dilution: (2) allowing very hot iron to stand; (3) use of the electric furnace; and (4) soda-ash treatment. There is a second useful article on "Manganese Bronze Test-Bars."

Sand Testing with Special Reference to Deformation*

By Wm. Y. BUCHANAN

The author's last Paper on this subject, given to the Scottish Branch of the Institute of British Foundrymen, was presented in January, 1932, and the work for it was carried out in 1930 and 1931. At that time the British Cast Iron Research Association had completed a good deal of experimental work, leading to some definite conclusions which were slowly having effect on foundrymen in this country. The Paper referred to was one of the first to draw attention to the verification of the main conclusions drawn by the B.C.I.R.A. as to the value of milling on a practical scale, and this particular time saw the beginning of a period of intensive study of sands and testing, followed by an equally intensive reconditioning of foundry plant to improve foundry conditions. Sand handling and reconditioning plant played a very important part in the revival of the foundry from the trade depression conditions and the value of milling was clearly recognised in the best composite sand handling plants.

There is no need to modify the conclusion reached in the earlier Paper that the two-roller

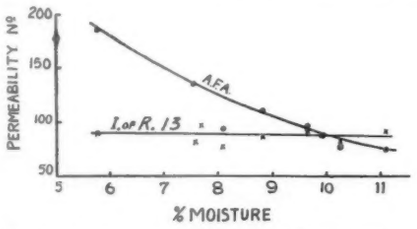


FIG. 1.—EFFECT OF MOISTURE ON PERMEABILITY OF ROCK SAND AS MEASURED BY A.F.A. AND DOUBLE COMPRESSION AT INDEX OF RAMMING 13.

type of mill is the most important part of any sand-preparing plant dealing with clay-bonded sands.

Technologists have continually argued amongst themselves in the committees set up to decide on the best methods of testing and procedure, but this is not surprising when it is considered that sand testing is amongst the most difficult forms of mechanical testing to perform with the degree of precision one associates with mechanical testing of metals, for example. This statement will be the more readily acknowledged the more one learns about the subject. The subject is not one which can be tackled by mere deduction and argument. It must be studied by extensive systematic experiment.

The vast amount of work done and on record both in America and other countries, as well as in Britain, should inspire considerable respect for the subject in the mind of the beginner. It should be stressed that it is not wise for anyone to begin sand testing and immediately adopt an uncompromising attitude, such as one occasionally finds, namely, that the foreman or underforeman is always wrong if he does not agree with one's test results, because he may not know how the A.F.A. permeability number is determined. If he does not agree, then he is entitled to a reasonable explanation of the new point of view, and if that is unconvincing to him, it is possible there is something wrong.

Sand testing is by no means above ambiguity, as the author has shown in several Papers to the Institute, and it is none the worse for the support of practical trials and the criticism of trained moulders who have risen to executive position. More success is likely to result where the older foundryman follows the proposed change with enthusiasm and the feeling that he has contributed to that success. The criticism of the more conservative foundrymen is always valuable, even if its only merit is to restrain the would-be headlong progress which may lack balance. The Institute serves a very useful function in the author's opinion by the facilities it gives for criticism of new ideas. With reference to the Paper of 1932, one or two points might be recapitulated.

* Paper read before the Scottish Branch of the Institute of British Foundrymen.

Preparation of Sand Sample

It was stressed that the treatment prior to testing had an influence on the test results and these remarks still hold good. The sand to be tested should be sieved and kept in an air-tight tin and placed in a mixing drum during testing. By this means no loss of moisture will occur even in a well-heated room. When testing sand with varying moisture contents it seems to be common practice to mill the sample to disperse the moisture, but if this be done it should be remembered that the effect of milling alone is very important, and care should be taken to assess the value of these variables separately.

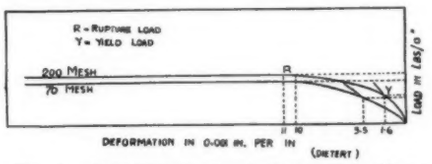


FIG. 2.—EXAMPLE OF DEFORMATION AND YIELD POINT MEASUREMENT (DIETERT).

Rate of Loading the Test-Piece in Compression

As then found, the rate of loading does not seem to have much effect on the compression strength on the 1¼-in. test-piece, but working with the A.F.A. test-piece and measuring deformation it is better to avoid variations in the rate of loading.

Mould Hardness

The principle of testing mould hardness as a means of producing a test-piece representative of foundry practice is still quite sound, but the attempt to measure moisture by mechanical test, like many others with the same object, has not been fruitful. However, the penetration method of measuring ramming density has been shown to be much more reliable than the skin hardness test.

The Test-Piece Controversy

In a Paper to the Birmingham Branch the 2-in. by 2-in. test-piece and the 1¼-in. dia. by 2¼-in. test-piece were studied, and it was shown that the test-piece with its length twice the diameter was the correct shape, the A.F.A. 2-in. by 2-in. test-piece being too short in proportion. The many defects in the A.F.A. test-piece were tabulated and discussed, and these should be kept in mind. However, since the A.F.A. test-piece is most commonly used by those in the committees dealing with the matter it must be accepted as the standard, for general use.

The distribution of ramming force in the A.F.A. test-piece by the standard drop-weight method is not too satisfactory, as the layers may vary from 20 to 3 hardness ratio. The same test-piece by double compression has hardness practically equal throughout, that is a ratio of 3 to 2 hardness.

By ramming the A.F.A. test-piece whilst allowing the tube to move with the last blow, the distribution of hardness is improved very materially, and a ratio 35 to 20 is given, although it has a hard layer on top. This improved method is used for this Paper as the standard A.F.A. test, since it can be compared with the test-pieces made by double compression to index of ramming 13. The 1⅛-in. dia. by 2¼-in. test-piece is now being used for high-temperature work in preference to the 2-in. diameter because it is admitted to be a better test-piece. It is rammed by double compression, or so-called double end ramming, using a special A.F.A. rammer.

The double compression mould and plungers for making the 1⅛-in. by 2¼-in. test-piece being supplied are still of inadequate design and insufficient accuracy. The mould or tube should be of steel, highly finished in the bore, and should retain the flange at one end as it is more convenient. The plungers should be case-

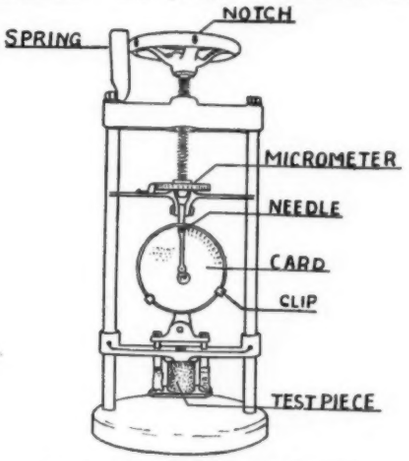


FIG. 3.—ARRANGEMENT FOR GRAPHING DEFORMATION UNDER COMPRESSION LOAD.

hardened and ground to a minimum of clearance giving an almost air-tight fit. The tube should be 8.256 in. long with one plunger 6.000 in. long and one 1.000 in. long, and the bore of the tube 1.128 in. The distance pieces should be horseshoe-shaped, of $\frac{1}{16}$ in. mild steel, as shown in the original illustration. Finally the test-piece should be made by simple pressure and not by blows of a mallet; this is important. The same remarks apply to making the 2-in. by 2-in. A.F.A. test-piece by double compression.

The question of what a standard ramming is has been raised at various times since 1932 in committee, it being said that the A.F.A. method gives a standard ramming, and that this represents normal foundry practice. There is a tendency to introduce different shades of meaning into the words "standard ramming" when discussing this aspect of sand testing.

To clarify this the A.F.A. procedure may be referred to as a test-piece made by a standard ramming machine, where the machine only is standard, the degree of ramming varying with all conditions. The index of ramming method, on the other hand, aims at controlling the degree of ramming.

The question as to which is more rational or representative of foundry practice resolves itself into a question of whether moulding is controlled by the energy expended in ramming to the exclusion of variations in the resulting mould or by trying to control the *results* by varying the ramming energy when necessary. The author contends that moulders work to the latter method. For example, if a sand is heavy and tends to ram too hard with the normal number of blows on a jolter, the number of blows would be reduced in order to secure a reasonable hardness.

Index of Ramming

The index of ramming is a number denoting the ratio of the porous rammed sand to the true density of the sand materials. It is a method of expressing the degree of ramming which is quite different from the idea underlying the A.F.A. method. It is defined as—

$$\text{Index of ramming} = \frac{\text{Dry apparent density}}{\text{True density}} \times 100 - 42.$$

Making test-pieces of varying dry apparent density, it will be seen that at between 1.1 and 1.2 the zero of ramming is reached and the fraction $\frac{\text{Dry apparent density}}{\text{True density}}$ then equals 42. This is not an arbitrary figure but one found by careful experiment. By deducting 42 a figure is obtained which the author has called the index of ramming. The range of ramming is thus 0 to 20, and the average for foundry practice found by trial is 13 index of ramming. The A.F.A. test-piece rammed by drop weight is subject to variations of ramming due to flowability, resulting from changes of water, clay, grain size and grain distribution.

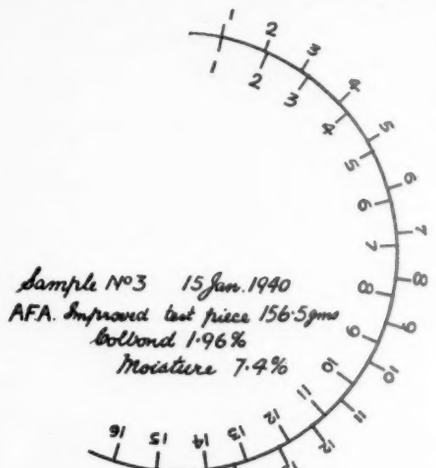


FIG. 4.—SPECIMEN CARD FOR DEFORMATION TEST.

Using the A.F.A. test-piece made by drop weight and the A.F.A. test by index of ramming, the true effect of flowability can be separated. In addition the effect of degree of ramming can be studied. Examples of this were given in the Birmingham Paper. Water does not close up the air spaces in the sand as is supposed, but goes to increase the plasticity of the clay, which causes the sand to ram harder under the A.F.A. rammer. When this variable is eliminated the true effect of the water will be seen to be nil, as shown by the graph (Fig. 1) at the index of ramming 13.

Whether or not this method becomes generally used does not matter very much, but it is useful for research on the effect of variables. It gives an explanation of many obscure points connected with testing, and apart from this it has a considerable educational value which should be beneficial to those taking an interest in the subject.

Modification of Tests in General Use

Green Strength.—In the old type of B.C.I.R.A. compression apparatus, the pan of the balance moves sideways. It was re-designed after Parkes showed the cause of slightly low readings. In the new B.C.I.R.A. machine a tension spring balance is used instead of the compression type, and agreement can now be had when using either pendulum or hydraulic machines for testing green strength.

Permeability.—The B.C.I.R.A. permeability apparatus is quite good, but the distance of the mercury seal from the manometer should not be too great, or a false reading may be registered, due to friction in the air tube.

Dry Strength.—The drying oven illustrated in a previous Paper does not require a fan, as it gives the necessary changes of air, and does not cool on opening the door. It reaches the temperature in 9 min., and can be regulated to any fixed temperature from 80 deg. up to 300 deg. C. and higher. The hydraulic testing machine for dry sand and oil sand up to 7,000 lbs. is very successful, and the principle was used by several others after it was proved successful.

Moisture.—Dietert's Moisture Teller is used by the author, as he believes it to be more accurate and quicker than other types of moisture meter he has tried, although it is, strictly speaking, not portable.

Sieve Test.—There is little new in this line, and it is still difficult to get agreement between different workers. In any case, however, clay should first be washed out.

Flowability.—There is as yet no standard method in America. Dr. Ries of Cornell University in a recent Report emphasised the necessity for study of this property. The method used for this Paper is to make a 2½-in. by 1½-in. test-piece of the same density as the A.F.A. test-piece by single compression, *i.e.*, filling the tube and squeezing it in one direction only. This test-piece is then tested, top and bottom, for hardness (skin hardness), and the bottom hardness expressed as a percentage of the top hardness. Thus, if the top and bottom were equal the flowability would be 100 per cent. A distinct relation is shown between this flowability test figure and the deformation test. This is brought forward for consideration of the Institute.

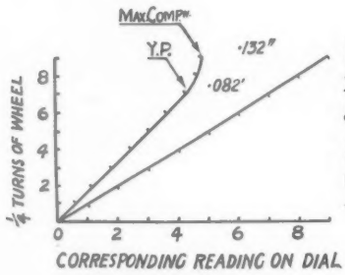


FIG. 5.—DEFORMATION GRAPH FOR OIL SAND.

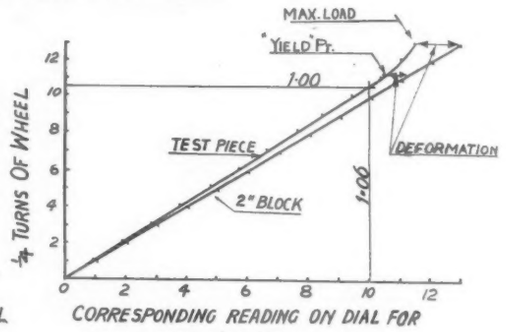


FIG. 6.—DEFORMATION GRAPH FOR GREEN SAND.

Mould Hardness and Ramming Density.—The Dietert skin hardness tester measures an impression made in the sand in thousandths of an inch, whilst the penetration tester measures the degree of ramming more faithfully than the other, the penetration being reported in millimetres.

Tensile and Transverse Tests.—These are not much used as they do not seem to have added to knowledge of sands. They are not required as an addition to the compression test.

Deformation, Yield Point and Plasticity.—The deformation and yield point test was put forward in the Birmingham Paper, and the method was described there. Although the B.C.I.R.A. machine is changed to a tension balance, the method of working remains the same.

Deformation

Deformation has been said to be that property which plays an important part in the stripping of moulds where inaccuracies of draft are present. It also prevents "drops" as the moulding box distorts in lifting. The deformation gives flexibility to sand on parting the mould, to take up inaccuracy of the mould at the parting, and also in being able to deform sufficiently to receive considerable core print pressure without failure. These will be readily endorsed by experienced operatives. Moreover, deformation plays an unfavourable part in that it allows molten metal to swell the mould. It also has the tendency to open up the mould at the parting during filling.

This requires some qualification as sand in the mould is usually reinforced and this will offset deformation to some extent, whereas A.F.A. test-pieces during compression are not reinforced. To illustrate this a green-sand test-piece was tested for deformation and compression strength, and it was found to have a deformation of 53 thousandths when loaded with a maximum of 27 lbs.

Another test-piece was left in the ramming apparatus and loaded with a further 50 lbs., *i.e.*, 50 lbs. plus the weight of the rod and rammer. This additional load on the test-piece, in the tube only, produced a deformation of 2 thousandths of an inch, which, strangely enough, disappeared on removing the load as though the test-piece had a minute amount of elasticity. This may confirm the view expressed by Pearce in the discussion on the Paper given in Birmingham.

In moulding, it is seldom that the sand under pressure would be so well supported as this but much more seldom would be the case of sand loaded by liquid metal only on the end and entirely unsupported on the sides. This experiment serves, however, to illustrate the difference which may exist between test and mould conditions, and this applies to all sand testing. Swelling in green-sand moulds is encouraged by lack of ramming, and the degree of ramming is quite separate from considerations of plasticity or deformation testing.

Assessing Moulding Quality of Sands

The green compression strength test has on close study appeared to be unsatisfactory as the figure obtained could be misleading. For example, a dry powdery sand could give a good compression strength but be unfit for moulding, whereas certain strongly-bonded plastic sands give a low compression strength and at the same time are ideal for moulding and patching. The measurement of deformation during fracture has been introduced in America as a measure of this plasticity and, when considered together, the maximum compression strength and deformation give a clear idea of the moulding quality of the sand.

This is analogous to the tensile and elongation measurement in metal testing. Copper and cast iron may have nearly the same tensile strength and without the elongation figures would give an impression of similarity which does not exist. The deformation test is therefore highly desirable and none the less so because it may appear difficult to carry out.

The yield point was also measured and this was claimed in America to be very important as the load at which swelling occurred in green

sand. This again is analogous to the elastic limit in metal testing, or at least is thought to be so, but as will be shown later, no elasticity exists in sand under compression *testing*. (This is not intended to contradict the previous statement.) The example (Fig. 2) taken from Dietert's Paper shows the graphs curving steadily from zero and the marking of the exact yield point must be treated with reserve for the time being.

The micrometer fitted to the B.C.I.R.A. type of compression frame was first constructed about 6 years ago to measure moisture by deformation, and when the frame was redesigned by the B.C.I.R.A. the deformation test measurement was revived. The deformation and yield-point test were suggested as a normal procedure for the consideration of the committee, and they evidently gave the matter their attention, comparing the results obtained by the suggested method on the B.C.I.R.A. apparatus and

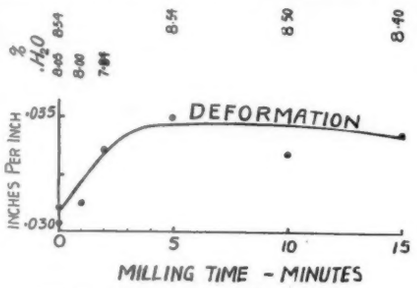


Fig. 7.—Effect of Milling Time on Deformation.

apparatus of American manufacture or design. Many or all of the workers who tried the measurement of deformation gave it up or at least shelved the matter indefinitely.

The author is informed by Mr. Parkes, of the B.C.I.R.A., that four laboratories, using different machines, returned figures on the same two sands as follows:—

1st Laboratory	0.034	0.056
2nd ,, ...	0.027	0.034
3rd ,, ...	0.140	0.100
4th ,, ...	0.040	0.046

With figures so divergent as these, the general recommendation of the test is, of course, impossible in its present state. Nevertheless, the test was thought to be so important as to justify further study, and the following work was carried out to find the possible causes of these differences and to eliminate the errors by improving the technique.

In order to understand the manner in which the deformation takes place under varying conditions, it was thought desirable to get some continuous measurement of this deformation during the compression test, and as at one time it was thought that this method might be applicable to general testing, considerable trouble was taken to simplify the method of operation. Several methods were tried, but the simplest form is illustrated in Fig. 3.

In order to get the deformation, two readings are required simultaneously, and as this is rather difficult, if not impossible, one was made by sound, leaving the operator free to keep his eyes steadily on the other.

A spring was fixed on the top of the frame, and the hand wheel was nicked at each quarter turn equal to 31 thousandths vertical movement. The usual pointer on the spring balance was removed and one carrying a suitable needle inserted in its place. A card, cut to the shape of the brass dial, was slipped behind the pointer. Then, using a 2-in. block as the test-piece, the hand wheel was turned steadily for the purpose of depressing the needle at every click, *i.e.*, every quarter turn. This gave the set of points in which the travel of the hand wheel was reproduced on the card shown in Fig. 4. The same procedure, using the sand test-piece, gave a set of points lagging behind by the actual amount of deformation. Intervals of a quarter-turn of the hand wheel were found to be convenient, but smaller divisions could have been selected. The zero might come between two quarter-turns, this causing a slight deformation reading at the beginning which really does not exist, and so the wheel was turned till the zero came after the first quarter-turn position.

The maximum compression always occurs a little after the last point marked, so that the graph does not give the exact figure. It is, however, not very far away and the graph itself gives all the information required. If a loose pointer be used, of course, the end point can be marked quite easily. The rate of loading is easily kept uniform throughout the test and from one test to another.

Plotting the points for the sand test-piece and the 2-in. wood block on the same paper, the deformation graph is seen to start deviating from the lowest possible loads in all three types of sand.

In oil sand and some strongly-bonded sands like Scottish rock sand, the yield point is, as is shown in Fig. 5, considerably lower than the maximum compression strength, but in green sand (Fig. 6) it is usually equal to or very slightly below this maximum. The so-called "yield-point" is actually the beginning of fracture, but strictly speaking the yield begins at zero load in all sands tested in the green state.

From this it is obvious that the yield point as a test can be neglected as it serves no useful purpose. Swelling as such would begin just above no pressure and be proportional to the load and could only be offset by the degree

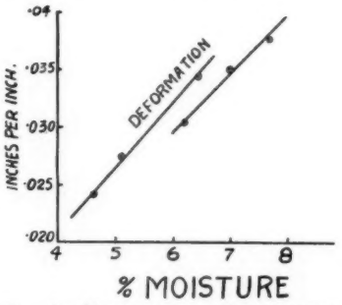


Fig. 8.—Variation of Deformation With Moisture in Rock Sand.

of ramming and suitable reinforcement. Several methods of interpreting the graphs were tried, as shown in Fig. 6.

(*A*) *Deformation at Yield Point.*—This was got by drawing the straight line through the points from zero and noting the point at which the graph left the straight line. This was expressed in thousandths of an inch deformation. Another method was to express the yield point and maximum compression strength in lbs. per sq. in. and take the ratio of the difference between these to the maximum compression as the degree of plasticity.

i.e., $\frac{\text{M.S.} - \text{Y.P.}}{\text{M.S.}}$ = degree of plasticity.

(*B*) *Deformation at the Maximum Compression Strength.*—The yield point seemed more accurate than the maximum compression strength owing to the uncertain end point.

(*C*) *Deformation from the Gradient of the Graph.*—This gave a simple ratio of, for example, 1.06 where no deformation would read 1.00. This graphic method was tried out extensively on the effect of moisture, ramming, bentonite and Colbond additions, and grain size mixing, but was found unsatisfactory when carried out in single tests. As a routine testing method, it seems too long and its lack of success seems due to the necessity for duplicating. This duplicating is essential in all sand testing, but the plotting of numerous graphs does not make the test very attractive.

However, it does show clearly that the deformation is always proportional up to the yield point, and for all practical purposes the maximum load is quite suitable for the measurement of deformation. This method has been described to give a clear idea of the way in which deformation occurs, and at the same time the record of the method may save someone else raising the same proposition later on. It was therefore decided to return to the method recommended in previous Papers and remove any possible errors.

Manipulative Difficulties

The first fact which becomes painfully obvious to anyone trying to measure deformation is that one thousandth of an inch is a very short distance, and this is more particularly obvious when measuring pieces of rammed

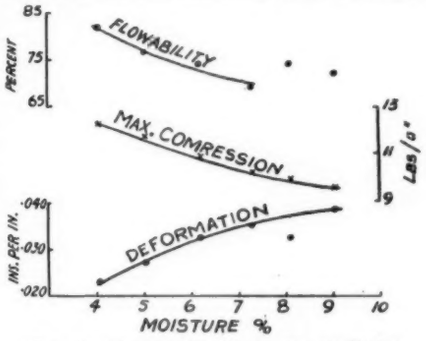


Fig. 9.—Effect of Moisture on Flowability, Maximum Strength and Deformation, When Using the A.F.A. Testing Method.

sand. The sand test-piece and wood block are always considerably different in length, and must be measured each time a test is done. A loose pointer was fitted to the balance, and both the pointers ground to a fine point to facilitate accurate reading, as the smallest division on the brass dial is equal to 4 ozs., which in turn is equal to four thousandths of an inch in the length of the test-piece.

In order to read the length of a test-piece accurately, the reading should be taken with a load of 1 lb. to make sure that all the backlash is taken up. The test-piece must be quite smooth and square on the ends, and this requires good accurate dimensions in the test-piece mould, stripping posts, etc. There should be no loose particles of sand on the ends, as these will cause differences in length of about ten thousandths of an inch.

The rate of loading in this method is inclined to be faster than the card plotting method, and it might be better to recommend a definite rate of loading for the guidance of users of the apparatus—for example, 2.5 lbs. per sec. using a 56-lb. balance.

The measurement of the A.F.A. test-piece is, of course, essential, because even with the greatest care and under the best conditions considerable variation in length is encountered. For example, in test-pieces made one after the other from the same sand, the following differences in micrometer readings were recorded:—

Sand No. 1 ..	116	107	122	118
Difference ..	9	0	15	11
Sand No. 2 ..	107	105	85	100
Difference ..	22	20	0	15

In the first example the readings showed a maximum difference of 15 thousandths in the duplicates, and in the second example a maximum difference of 22 thousandths of an inch.

In the index of ramming method using the A.F.A. test-piece made by double compression, where the test-pieces are made a definite length, the accuracy of duplicates is much better. The

following records the differences in micrometer readings of two samples, A and B:—

Sand A	..	101	99½	101	102
Difference	..	1½	0	1½	2½
Sand B	..	100½	98½	97½	100
Difference	..	3	1	0	2½

Accuracy of Duplicates

In the measurement of the wood block, the readings taken one after the other (108, 108, 108, 109, 107.5) were obtained, which means that the accuracy of measurement of fixed distances by this apparatus is very good indeed. The following figures were reported using repeat tests by two operators, X and Y.

X's figures				
Max. compression, lbs. per sq. in.	25⅜	25⅛	26	25⅞
Deformation (thous.)	49	53	50	49
Y's figures				
Max. compression ,, ,,	23	23		
Deformation (thous.)	52	51		

Thus, the agreement between operators is very good, and the duplicates for one operator are also satisfactory. It is also evident that the use of four readings per test will produce a good average. This is quite usual in sand testing, and where one of the duplicates is obviously out, it can be negelected as is the usual practice. The readings may be considerably improved after a day's practice, *e.g.*, 62½, 60½, 60½, deformation on 2 in. in thousandths.

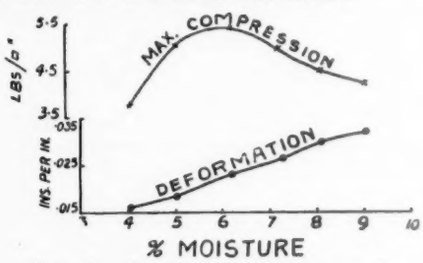


FIG. 10.—EFFECT OF MOISTURE ON DEFORMATION AND MAXIMUM STRENGTH TESTED AT INDEX OF RAMMING 13.

This means reading to the half thousandth, which may be derided but which is not so far-fetched as it sounds, because the divisions on the micrometer scale are equal to about ⅛ in. and are easily subdivided.

Most of the work done for this Paper on deformation has been confined to the actual details of the methods, its accuracy, etc., but it was thought advisable to include some examples of its application to common variables such as moisture variation, variation of clay content, etc.

Effect of Milling on Rock Sand (Two-Roller Mill)

A large quantity of Scottish rock sand was well turned-over, heaped and levelled to ensure uniformity in moisture and constant temperature; batches were taken from this for the milling experiments. The same weight was taken for each batch and the milling time was varied. After completing the milling time, a sample was taken and the batch discarded, a fresh lot being taken for the next batch. The samples were sieved and returned to the air-tight tin.

The graph (Fig. 7) shows an increase in plasticity or deformation to a maximum in about 3 minutes and indicates no further increase beyond that. The green strength continues increasing from 8.2 lbs. per sq. in. as received to 13.6 lbs. per sq. in. with 15 minutes milling. This may indicate that the lack of aeration of the samples after milling allows the excessive packing to be transmitted to the test-piece. The deformation test is probably a better method of judging the efficiency of the milling operation, and this particular example denotes very efficient mixing.

Effect of Moisture on Rock Sand

A batch of rock sand was first milled to develop the maximum plasticity at the particular moisture content, and then additions of water were made, followed by further milling. This was repeated on another batch of very low moisture content. The results as shown by Fig. 8 in each case record a sharp increase in deformation with rise in moisture content. This is easily explained as moisture would be expected to increase the plasticity of a clay-bonded sand. As shown, 1 per cent. moisture increase raises the deformation by 0.005 in. per in.

This was repeated using new batches instead of adding more water to the same batch for further milling. The results recorded in Fig. 9 using the A.F.A. improved drop weight ramming show the same rapid increase in deformation with a corresponding decrease in compression strength. It is interesting to note that the flowability has dropped as the deformation rises. This suggests that the A.F.A. test-piece rammed by drop weight alters considerably with the flowability of the sand, as stated in a previous Paper.

The tests on these samples were repeated using the double compression on the A.F.A. test-piece at index of ramming 13 (Fig. 10), and it will be observed that the deformation curve is the

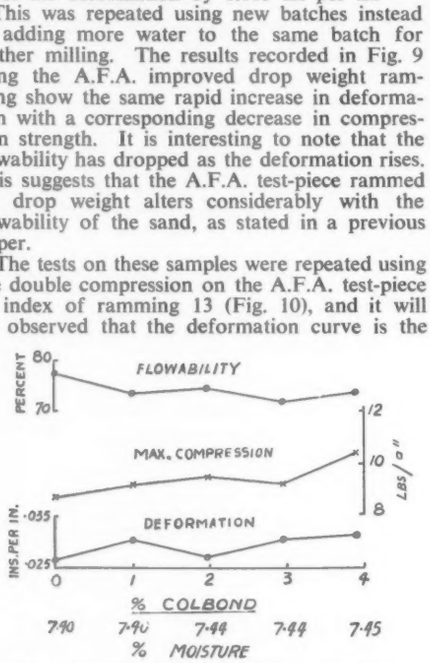


FIG. 11.—EFFECT OF ADDITIONS OF CLAY TO GREEN SAND TESTED BY A.F.A. METHOD.

same but the maximum compression strength is quite different, showing an increase in strength up to 6 per cent. moisture and above that a decrease. There is a considerable difference in the weights or degree of ramming by the two methods, but the A.F.A. test, when used upon this type of sand, gives a test-piece which seems too hard for good moulding.

Effect of Colbond Additions to Green Sand

Here again a large quantity of green sand of the Erith type was mixed, heaped and levelled to make it quite uniform; then batches were taken and milled with varying quantities of Colbond from 0 to 4 per cent. Care was taken to keep the moisture the same and to mill in each case for exactly two minutes. The tests detailed in Fig. 11 were carried out on the improved A.F.A. test-piece. Over-all, the maximum compression strength is raised about 2 lbs. per sq. in., while the deformation is not decisively raised. It will be noted, however, that the flowability again follows the exact opposite trend to the deformation, as though the curves had just been reversed.

Conclusions

(1) Deformation is definitely related to the percentage flowability as expressed by the methods put forward.

(2) Deformation should be used as a method of judging mixing efficiency.

(3) The deformation test is useful and a good figure for normal practice should be easily established, *e.g.*, 0.025 in. per in. for Scottish rock sand.

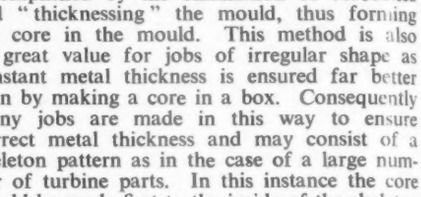
(4) The A.F.A. compression test is affected by flowability, and this should be taken into account when assessing the value of such variables as moisture, milling, grain size, grain distribution and bond.

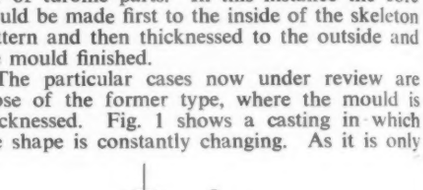
Thicknessing Methods

BY "FOUNDRYMAN."

In normal production most jobs are produced from patterns and coreboxes, but occasions arise in which patternmaking time has to be economised and the casting produced with the minimum of patternwork. This can often be accomplished by the elimination of coreboxes and "thicknessing" the mould, thus forming the core in the mould. This method is also of great value for jobs of irregular shape as constant metal thickness is ensured far better than by making a core in a box. Consequently many jobs are made in this way to ensure correct metal thickness and may consist of a skeleton pattern as in the case of a large number of turbine parts. In this instance the core would be made first to the inside of the skeleton pattern and then thicknessed to the outside and the mould finished.

The particular cases now under review are those of the former type, where the mould is thicknessed. Fig. 1 shows a casting in which the shape is constantly changing. As it is only





a one-off job a rough pattern with core-prints attached is supplied. This is moulded in the normal way and dried. The flange being filled with parting sand, the whole is clay-thicknessed. This consists in making in a suitable wooden box a large number of slabs of clay approximately 6 inches square and the thickness of the casting. These are then laid over the mould and the joints smoothed down. Being lined with paper, a core is now made in the usual way on a suitable grid and dried. This is subsequently lifted, the clay removed and the mould cleaned out. The core, having been blackwashed, is assembled in the orthodox manner and the job cast.

Another case in which thicknessing can be applied is shown in Fig. 2, which is a section of a special type of soleplate. As the casting was required urgently and each subsequent one would probably be different, to suit a different motor, a full pattern which could be easily altered was supplied without a corebox. After the mould was made it was lined as in the former case with clay to the thickness required and a core made on a suitable grid. This method, while taking a little longer in the foundry, avoids the expense of a considerable amount of patternmaking and also expedites the delivery of the casting and is applicable to a large number of cases.

I.B.F. Diploma Award to West Yorkshire Members

At the February meeting of the West Riding of Yorkshire Branch of the Institute of British Foundrymen, held in Bradford Technical College, Mr. A. W. Walker (past Branch-President) and Mr. S. Carter (Branch-President) were presented with the Institute's Diploma for their joint Paper to the Branch in 1938 on "Moulding Sand with Special Reference to Blind Scabs." Mr. A. S. Worcester (also a Branch-President) made the presentation to the two authors, who expressed gratification that such honour had come to the Branch.

Copper in Cast Iron

By TOM BARLOW

(*Continued from page* 182.)

The analyses of cast iron that are included in Table I are typical examples of some of the copper alloy cast irons now being used. These analyses do not pretend to cover all the variations which can be utilised with economy but merely serve to illustrate the way in which the unusual characteristics of copper cast iron can be employed.

No. I relates to the Ford cylinder block and is typical of that used for cylinder blocks by many other manufacturers. In this case 0.75 per cent. copper is sufficient to ensure the section uniformity and machinability that is desired in these castings. As pointed out in the quotation from the Paper by McCarroll and McCloud* of the Ford Motor Company, this iron also has a better wear resistance than that found in the unalloyed irons, but the effect of copper on uniformity throughout the various sections is the prime consideration.

TABLE I.—*Typical Examples of Copper-Alloy Cast Irons.*

Type no.	Composition. Per cent.				Tensile strength. Tons per sq. in.	Use.
	T.C.	Si.	Mn.	Cu.		
I	3.15–3.40	1.80–2.10	—	0.75	13.3–16.0	Cylinder blocks.
II	3.30–3.60	1.40–1.80	1.0–1.25	0.75	14.2–17.0	Flywheels, etc.
III	3.20–3.40	1.40–1.60	—	1.25–1.75	15.1–17.8	Gears, etc.
IV	3.10–3.30	1.40–1.80	—	1.75–2.25	17.0–20.0	Heavy machinery.

No. II is typical of castings such as flywheels where unusual density is required in a casting having rather drastic changes in section size. It should be noted in this iron that the carbon and manganese are relatively high, combined with the fairly low silicon and 0.75 per cent. copper to maintain machinability. As pointed out in the Paper by McCarroll and McCloud, the same density could be obtained in these castings by the use of a lower silicon content and no copper, but in this case the casting would be difficult to machine as well as being subject to porosity in the heavy sections and cracks in the lighter sections.

No. III typifies such applications as gears in which good machinability is desired but somewhat greater density and wear resistance are necessary. These castings usually have definite changes in section size and are therefore liable to cracking and porosity unless some alloy such as copper is used to maintain the structural uniformity.

No. IV is well adapted to heavy castings in which the ability of copper in higher percentages to enhance density combined with good machinability is of prime importance. Unlike most other graphitisers, copper has a very definite tendency to close the grain of large castings, particularly in the higher percentages. The use of this amount of copper is normally accompanied by a substantial increase in the physical properties.

Copper-Chromium Irons

When higher strength, together with good toughness, low chill, extreme density, and good machinability are desired, the use of copper in combination with some other element is frequently the most economical method of obtaining the desired results. A number of such combinations have been investigated and are now being used commercially in increasing amounts. One of the most common of these alloy combinations is that of copper and chromium, of which two examples are as follow:—

Type No. V: T.C, 3.10 to 3.50; Si, 2.20 to 2.50; Cu, 0.80 to 1.20, and Cr, 0.25 to 0.50 per cent., having a tensile strength of 13.3 to 17.8 tons per sq. in.

Type No. VI: T.C, 3.15 to 3.40; Si, 1.80 to 2.10; Cu, 1.25 to 1.75, and Cr, 0.40 to 0.60 per cent., having a tensile strength of 15.6 to 20.0 tons per sq. in.

If the degree of chill is to be unaffected, copper and chromium should be added to cast iron in proportions of approximately 4 to 1. Additions of chromium alone strengthen and harden cast iron materially, but render it progressively more brittle and difficult to machine. If, however, they are accompanied by a balanced addition of copper, the strength increases to the same or greater extent, but since the formation of free carbide is prevented, the iron remains tough and machinable. When such a combination of chromium and copper is added to a ferritic base iron, the resulting iron tends to be pearlitic because the copper does not accelerate the breakdown of pearlite but merely prevents the formation of carbide due to the addition of chromium. If this same combination, however, is added to a base iron already containing free carbide or hard spots, extra copper would be necessary to break down the original carbide formation in addition to that required to compensate for the carbide formed by the chromium. For the most economical increases in tensile strength and other physical properties, copper-chromium combinations and other alloy combinations should be added to a pearlitic or balanced base iron whenever possible. Among the many applications of copper-chromium irons are brakedrums, machine-tool castings, valves, and pump castings. One specialised application is in heat-resistant castings such as furnace parts.

Type No. V iron is frequently used in such parts as pumps and compressors. It contains an approximately balanced ratio of copper and chromium. This combination permits higher physical properties than would be obtained from the unalloyed irons, together with greater density, resistance to pressure, and equal machinability. In a pump casting the use of this same composition is of importance due to increased corrosion resistance.

Type No. VI, typical of small brakedrums, hoist drums, and sheaves, contains a somewhat higher percentage of both copper and chromium to promote greater thermal stability and somewhat higher physical properties than could be obtained from Type No. V.

Copper-Molybdenum Alloys

Copper-molybdenum combinations have received favourable comment from many users. Two commonly used types are as follow:—

Type No. VII: T.C, 3.20 to 3.30; Si, 1.70 to 2.40; Cu, 0.75 to 1.25, and Mo, 0.40 to 0.60 per cent., having a tensile strength of 17.8 to 22.3 tons per sq. in.

Type No. VIII: T.C, 2.80 to 3.10; Si, 1.90 to 2.60; Mn, 0.80 to 1.25; Cu, 1.75 to 2.00, and Mo, 0.50 to 1.10 per cent., having a tensile strength of 22.3 to 35.7 tons per sq. in.

One application which calls for nearly 10,000 tons per year of copper-molybdenum cast iron in one foundry alone is that of large truck brakedrums. Type No. VII iron is used extensively for crawler crane drums, hoist drums, spill gate valves for corrosive waters, and other applications where high strength, wear resistance, toughness, and even corrosion and heat resistance are required. If the chill depth is to remain constant, copper and molybdenum should be added to the cast iron in approximately equal proportions, the exact ratio depending somewhat on the carbon content. However, in copper-molybdenum combinations, the copper acts to increase the strength and for economy's sake is usually added in more than equal proportions. Unlike the copper-chromium combination, copper tends to increase the Brinell hardness in the molybdenum irons when added in excess of 1 per cent. This combination permits very high strength, toughness, hardness, and wear resistance combined with good machinability.

One of the strongest cast-iron combinations in commercial use to-day is Type No. VIII. This iron is used for very heavy Diesel cylinder blocks and similar applications where extreme strength combined with very good wear resistance, density, and satisfactory machinability are of prime importance. This combination of alloys is used commercially in castings showing tensile strengths of up to 37 tons per sq. in. with a machinable Brinell hardness of below 300.

Copper-Vanadium Alloys

Another alloying combination which is rapidly coming to the front is that of vanadium and copper, of which a typical analysis is as follows:—

Type No. IX: T.C, 3.10 to 3.25; Si, 1.80 to 2.20; Cu, 1.75, and Va, 0.25 to 0.35 per cent., having a tensile strength of 20 to 26.7 tons per sq. in.

For any given hardness, a combination of 2 per cent. copper with 0.15 to 0.20 per cent. vanadium gives an increase of from 2 to 5 tons per sq. in. more than a straight vanadium iron. In other words, higher strengths are obtained with the same Brinell hardness with a copper-vanadium iron than with either straight copper or straight vanadium. These irons have excellent properties in respect to chill, microstructure, and physical properties. They have been used for brakedrums, and are beginning to be used for moulds to receive hot metal. The copper-vanadium combination has two important characteristics. The first of these is the ability of this combination to respond to heat-treatment. Such castings as stator housings, which must withstand excessive wear and should therefore have a very high Brinell hardness but which must be machined, can readily be cast with this combination of alloys to a machinable Brinell hardness and then readily heat-treated by a quench-temper treatment to the desired structure. Another characteristic of the copper-vanadium combination is the unusual uniformity of structure and properties in castings of various sections and castings from different heats. This combination is frequently recommended where the ability to reproduce the same properties from day to day is important and where uniformity of section structure is required.

Copper-Nickel Alloys

Another alloy combination that has received considerable attention in recent years is that of copper and nickel. Data obtained both in experimental foundries and in commercial foundries indicate that copper and nickel are very similar in their effect on Brinell hardness, tensile strength, and other physical properties of cast iron. However, there are certain essential differences between these alloys which frequently make the combination of the two desirable. The following analysis of a typical nickel-copper cast iron is well known in commercial practice at the present time:—

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* "Ford Alloy Castings," by R. H. McCarroll and R. H. McCloud, "Metal Progress," 1936.

Type No. X: T.C, 3.20 to 3.60; Si, 1.80 to 2.00; Cu, 0.75 to 1.00, and Ni, 0.75 to 1.00 per cent., having a tensile strength of 13.3 to 17.0 tons per sq. in.

The solubility of copper in cast iron is limited, but can be increased by the addition of nickel. For example, in the absence of other alloys, the amount of copper that can be satisfactorily dissolved in cast iron ranges from 2.5 to 4 per cent., depending somewhat on the composition and somewhat on the section size and cooling rate of the casting involved. However, when large amounts of nickel are added, the solubility of copper in cast iron can be increased to as much as 7 per cent. Therefore, in applications requiring large amounts of an alloying element such as copper or nickel, a combination of half nickel, half copper, or in the higher percentages, two-thirds nickel, one-third copper, is utilised to ensure good distribution of the alloy and complete solution of the copper.

For this same reason, combinations of copper-nickel-chromium, copper-nickel-molybdenum, copper-nickel-vanadium, etc., are frequently used in the highly alloyed cast irons.

Special Copper Cast Irons

Copper is frequently used in cast iron for special purposes, particularly heat and corrosion resistance. One of the better-known corrosion-resistant materials containing from 14 to 18 per cent. nickel with from 4 to 7 per cent. copper is unusually resistant to such corrosive media as brine, sea water, ordinary atmospheres, and many chemicals. Due to its unusual toughness and heat resistance, it also finds many applications for such purposes as cylinder liners, sleeves, and grates. Copper is used in this particular alloy combination largely for the purpose of decreasing the cost and increasing the corrosion resistance in some media.

Another fairly well-known corrosion-resistance application is that of copper cast-iron pipe containing from 0.75 to 1.50 per cent. copper, which is used particularly in condenser coils for oil refineries, mine water applications, and for acid resistance. Corrosion-resistant properties of copper cast iron are also taken advantage of in large spill gate valves and similar castings used in highly corrosive waters, such as would be encountered on the Monongahela River. These castings frequently utilise copper-molybdenum combinations to take advantage of the additional strength and density imparted by molybdenum.

Copper is finding increasing use in heat-resistance applications, particularly in combination with chromium. For these applications copper is effective in reducing scale formations at high temperatures and counteracting the embrittling effect of the chromium. A typical cast iron in this class would contain approximately 1 per cent. copper and 1 per cent. chromium.

A new complex alloy cast iron utilising the effect of copper on the transformation rates is that containing 3 to 4 per cent. copper, 1 to 2 per cent. manganese, and 0.5 to 1 per cent. molybdenum. This material has an as-cast hardness of between 400 and 600 Brinell even in large sections, but it can be annealed for machining purposes and then rehardened to its original as-cast condition. When cast against a chill, the extreme hardness of the white iron combined with good toughness renders this material suitable for resistance to excessive wear. This material is adaptable to liners, pistons, rings, and chill or grain rolls.

No discussion of special copper cast irons would be complete without mention of the development work done by the Meehanite Research Institute on the use of copper in Meehanite metal. Although the use of copper in Meehanite is probably not directly comparable to the use of copper in grey cast iron made by ordinary means, many of the applications developed by this company are of considerable interest. The Meehanite Research Institute has found that the use of copper in Meehanite metal permits higher hardness, greater strength, better wear resistance, together with good machinability. There are also numerous applications of heat-resistant Meehanite utilising the benefits and economies of copper as an alloying element.

Foundry Practice

The use of copper in the foundry is very simple if a few precautions which apply to any alloy addition are observed. Care must be exercised to keep the copper content below 2.5 to 3.5 per cent., unless a specific application calls for some free copper in the iron or unless a large amount of nickel is present, as in the case of Ni-Resist. Copper has a melting temperature of 1,082 deg. C., and therefore does not cause the blows, shrinks and other defects that sometimes result from the use of an alloy with a higher melting point than that of cast iron.

Copper is slightly heavier than iron, and consequently does not float on the top of the molten bath before being absorbed. Conversely, it should not be added to the bottom of the ladle before the molten iron is added, since it will not rise and be absorbed. Probably the most successful method of adding copper to cast iron is to introduce it into the spout of the cupola by means of a funnel or scoop. Another method which is used particularly in smaller ladles poured from a large bull ladle consists of introducing the copper at the base of the stream of iron after the bottom of the ladle has been covered with molten metal. If this is done, the consequent agitation is sufficient to ensure good mixing. No difficulty is had in obtaining good solution or dispersion of the copper in the molten iron, particularly in the presence of aluminium or nickel. The results obtained from the use of copper are extremely uniform, and no difficulty is to be expected from this source.

Many of the copper producers and other alloy manufacturers are now marketing a copper shot of a known high purity intended primarily for foundry use. This material is recommended for spout and ladle additions to cast iron If it is essential to add copper to a small hand ladle, it should be stirred vigorously or re-ladled in order to ensure complete solution. These precautions, of course, apply equally well to all ladle additions of alloys. In fact, the experience of many foundrymen using copper seems to indicate that copper goes into solution and into complete dispersion more readily than do most alloys.

When copper scrap is used, it should be of a size compatible with the amount of iron in the ladle, the percentage being used, the temperature of the metal, and the general foundry practice. The higher metal temperatures, of course, are capable of dissolving heavier material. Unless rather high temperatures are employed or unless the amount of iron being treated is fairly large, it is undoubtedly best to use a material such as copper shot. In any event, the purity of the copper should be ensured since although copper itself does not introduce foundry difficulties, some of the impurities in copper scrap may do so.

A new copper alloying agent developed by the Copper Iron and Steel Development Association consists of copper, silicon and a small amount of aluminium. It can be crushed readily to a small size and is particularly adapted for ladle use. The melting point of this material (815 deg. C.) is also an asset in this regard. This alloy addition imparts the usual copper effects—it also has a deoxidising effect which tends to prevent the formation of dendritic graphite and the modification of cast iron. In many cases, particularly in the lower-carbon cupola irons and electric-furnace cast irons, it is possible by means of this alloy to get increases in physical properties impossible by the use of copper alone. Increases in toughness over 125 per cent. have been observed in commercial practice as well as in laboratory tests, together with increases of up to 60 per cent. in tensile and transverse strengths.

Copper can also be introduced into cast iron by adding it to the charge in the cupola. In this case, baled or briquetted copper scrap, fairly large chunks of copper plates, or sheared cathode copper are recommended. A fairly coarse copper wire has been used in the cupola with complete success, although this cannot be particularly recommended. Apparently the low melting point of copper, which would lead to the suspicion that it might come down prior to the original charge with which it was placed, does not have this effect if the copper is placed on top of the metal charge. Cupola and furnace additions have been wholly successful. Usually, of course, due to the foundry conditions and also to metallurgical considerations, a ladle addition is preferable, but at times the amount to be added is too great for good foundry practice.

Whether copper is added to the cupola, to the ladle, or to the cupola spout, there is no loss due to oxidation. A saving in the total alloy cost can be made by considering the amount of copper in the remelt, since this is not lost during the melting process. Up to 2.5 to 3.5 per cent. there is no tendency for copper to separate out of cast iron or to segregate in one spot. Instances of segregation, separation or loss are probably purely mechanical, resulting from improper material or faulty manipulation. When copper is added to cast iron with the same care and regard used for other alloys, no trouble occurs, and its benefits and economies can readily be realised by the foundryman.

Catalogues Received

Improved Physical Properties. A four-page leaflet received from the Carborundum Company, Limited, Trafford Park, Manchester, deals with Ferrocarbo, and presents points of exceptional metallurgical interest. Essentially the material incorporates silicon carbide, and this compound at a temperature of 1,315 deg. C. dissociates into its elements, liberating nascent silicon and carbon. The reviewer agrees with the claims that (1) it softens hard iron, (2) has an exothermic reaction and so yields a hotter iron, but because of recent trends in metallurgical thought he is uncertain as to whether cast iron ever requires deoxidising. What does appeal strongly is the potential effect of the nascent silicon and carbon, and it is easy to visualise marked amelioration. It is precisely these speculations which make this leaflet so interesting and worthy of more than just perfunctory perusal. On these grounds it is suggested that it is well worth while writing to Trafford Park for a copy.

Pumps. Amongst four catalogues received from the Harland Engineering Company, Limited, of Alloa, dealing with all types of pumps, there is one of special interest at the moment. It covers a new line of trailer fire-fighting pumps, which must be much cheaper to buy than an engine which incorporates its own motive power. With the general availability of the ordinary car, a modern trailer pump suffers few if any drawbacks.

Gravity Conveyors. Booklet 210, just issued by Herbert Morris, Limited, of Loughborough, is a non-specialised publication dealing mainly with roller pathways, though a few examples of shutes, overhead chains and cranes are included. The compiler must have been in a merry mood when preparing the contents for he has found a number of particularly happy expressions, such as "working without walking," "cakes and ale," "books, bolts or bricks." The extensive experience the firm has had in foundry mechanisation is illustrated by the inclusion of a number of pictures dealing with castings production.

Cast Iron and its Relation to Machine Tools*

By P. A. RUSSELL, B.Sc. (S. Russell & Sons, Limited, Leicester)

It is proposed to take full advantage of the title and treat the subject under two distinct headings:—(1) Cast iron as a material for the construction of machine tools, and (2) the working of cast iron upon machine tools.

Ordinary cast iron can be regarded as steel broken up by flakes of carbon, called graphite, but this steel may be of any quality from the almost carbon-free dead-mild type, through the strongest or fully pearlitic type with the carbon content at about 0.8 per cent., to the hardest cast steel type containing free iron carbide. This last may be present in large quantities and is the major constituent of hard white iron.

When the groundwork of cast iron consists entirely of pearlite, which occurs with a combined carbon content of 0.6 to 0.9 per cent., this groundwork is in its strongest condition and is also most responsive to heat-treatment.

Cast Iron for Machine-Tool Manufacture

Cast iron is the traditional material for the main constructional parts of machine tools for the following reasons:—(1) Ease of casting into fairly intricate shapes; (2) low cost, compared with other materials; (3) rigidity, and (4) reasonable resistance to wear, including its self-lubricating property owing to the presence of graphite and the penetration of oil into the graphite.

The advent in 1900 of high-speed tool steels, and still more recently the introduction of tungsten-carbide tools, has created a new set of problems in machine-tool design. These can only be met in part by the alteration of design, and improvement in materials is essential. It is therefore proposed to discuss the physical properties of cast iron from the point of view of machine-tool construction.

Strength and Rigidity

Ultimate tensile strength is of little importance in most machines as the sections required to obtain a rigid machine are such that failure by fracture is rare, except in accidental cases. The designer tries to keep his major stresses in cast iron compressive, but bending stresses are bound to occur. Thus the ordinary transverse test as used for cast iron may be a more useful guide than the tensile test. However, as so much depends in cast iron upon the tensile strength, it warrants prior discussion. Improvements in this property of cast iron have kept pace with the demands of machine tools. The old figures of 9 to 11 tons tensile which are quoted in most textbooks are out of date so far as machine-tool irons are concerned. This is not so much because the demand has been for stronger irons as because of the demand for sounder irons which has resulted in an incidental increase in strength.

It is now reasonable to demand that the iron for good machine tools should meet Grade 1 of B.S.S. 786 for High-Duty Cast Iron, giving a range of 12½ to 15 tons per sq. in. tensile strength over the various sectional thicknesses. For the highest quality of tools, Grade 2 with a tensile strength of 15 to 18 tons per sq. in. can fairly easily be met and should be sufficient to meet every demand except for parts carrying exceptional stresses.

A third grade with tensile strengths of 18 to 22 tons per sq. in. is available for these cases in certain special types of cast iron such as Ni-Tensyl or the higher grades of Meehanite. Even higher strengths can be obtained by heat-treating these materials. A typical range of irons for machine-tool castings with their physical properties is given in Table I.

TABLE I.—*Properties of Cast Irons for Machine Tools.*

Type of cast iron.	Tensile. Tons per sq. in.	Transverse R.S. Tons per sq. in.	Brinell hardness.	Impact. Ft.-lbs.	Relative machinability
Light for guards ..	10	23	210	5	0.08
Normal grade ..	14	30	220	7	0.08
Special grade	18	33	230	9	0.07
Ni-Tensyl ..	22	36	250	9	0.07
Ni-Tensyl heat-treated	28	36	320	9	0.06
Ni-tensyl + 0.5 per cent. Mo, heat-treated	31	44	350	10	0.04

Brinell hardness—3,000-kg. load, 10 mm. ball.

Impact test—on special B.C.I.R.A. machine using unnotched bar, single blow. Bar 0.798 in. dia. Striking height, 1.3 in.

Machinability—penetration in ins. per 100 revs. of Ardalloy tipped drill ¼ in. dia. under 51-lb. load, tested on special Herbert machine.

Much more important than tensile strength is the modulus of elasticity, *i.e.*, the amount of "spring." Shaw[1] has described "Every machine tool as a bundle of springs." Modulus of elasticity of the material plays a great part in rigidity; the higher the modulus the less the deflection under a given load. For example, an iron having a modulus of elasticity of 20×10^{-6} will extend 1/1,000 in. on a bar 10 in. long under a load of 2,000 lbs., whilst one with a modulus of 10×10^{-6} will extend the same amount under half this load.

The modulus of elasticity in cast iron increases approximately as the tensile strength increases. Thus the tensile strength may be a useful guide. But the modulus does not increase in direct proportion to the tensile strength, and rises from 11×10^{-6} for the weakest irons to about 20×10^{-6} for the stronger irons.[4] In the higher-strength irons the modulus varies considerably, and irons developed particularly for tensile strength do not necessarily have the best modulus of elasticity values.

Whilst the modulus of elasticity has been increased so that demands may be met, this increase has tended to reduce the capacity of cast iron for damping out vibrations. Damping capacity is an important factor about which very little is known. Ordinary soft cast iron has a very good damping capacity, whilst steel has a poor one. This is one of the major reasons why fabricated steel is not favoured for machine tools.

Such evidence as is available shows that the damping capacity of cast iron decreases as the tensile strength and modulus of elasticity increase. Thus, to obtain the rigidity necessary for the production of fine finish on parts being tooled, it is necessary to effect a compromise between the benefits obtained by a high modulus of elasticity and the corresponding increase in tendency to vibration. The presence of graphite seems to give cast iron its good damping capacity, which constitutes one reason why a very low graphite content is not desirable.

Resistance to Wear

The other factor which the speeding up of machine tools has brought into the forefront is resistance to wear. Increased speeds and frequency of motion, combined with increased demand for accuracy, have made this property of the utmost importance. Unfortunately, resistance to wear is one of the most difficult things to measure as so many factors are variable. They include: (1) lubrication, (2) pressures, (3) speeds, and (4) nature of opposing materials.

Cast iron is reasonably good for resistance to wear of the type met with in the sliding parts of machine tools, owing to its being in fact a fairly high-carbon steel broken up by graphite flakes. The graphite flakes act as a lubricant and a reservoir for the absorption of oil. The improvements in cast irons already noted have largely contributed to resistance to wear, particularly the improvement brought about by the change from the old soft type of cast iron to the harder "semi-steel" type, which really consists of the raising of the base of the cast iron from a mild steel to a high-carbon steel, accompanied by a reduction in the size and quantity of graphite flakes. It is by no means certain that the engineer's desire for a cast iron which has so little graphite that it is scarcely visible is really to the best advantage from the point of view of wear. Certainly, in the immediate post-war period, the reduction in graphite size and quantity indicated an improvement in quality, but this can be carried too far, and good wear-resisting iron should not be too low in graphite.

The improvements in wear resistance offered by the normal improvements in cast iron are not sufficient to meet the demands for the most exacting machines, and further methods were evolved.

One of the first was the densening of the important faces of the casting by placing in the mould an iron densener which increases the cooling rate of the metal, thus causing, locally, a higher combined carbon (*i.e.*, a higher carbon in the steel groundwork) and a lower graphite content. This also enabled closer-grained hard-wearing surfaces to be obtained on the "ways" of the casting than could normally be obtained. This is owing to the fact that these "ways" are usually of much heavier section than the rest of a casting, and the use of an iron to get the correct structure in these parts results in an unmachinable iron in the thinner parts.

Densening is still largely employed, and, provided that it is used intelligently and that the quality of the iron used is good and strictly controlled, it will meet the demands of the largest proportion of machine tools. Objections are frequently raised that the use of denseners puts strains into a casting, which are relieved on machining, causing ultimate warpage. It is a personal opinion, however, that, provided that drastic densening is not necessary owing to the use of a poor-quality iron, densened castings warp less than undensened ones. The chief cause of warping in castings is the unequal rate of cooling of thick and thin parts, and if the cooling of the thick part be accelerated by densening, so that it more nearly approaches that of the thin parts, it is natural to assume that warpage will be reduced.

The word "densener" has been purposely used instead of "chill," although the latter is the word commonly used. A chill, strictly speaking, is a piece of iron cast against the mould of sufficient bulk to accelerate the cooling of the iron so drastically that the iron becomes white and unmachinable. Such an iron is very hard and resistant to abrasive wear but is not really suitable for machine tools, although attempts have been made to use it. Machining and warping problems become acute. The

* Paper presented to the East Midlands Branch of the Institute of British Foundrymen, Mr. R. Buckland presiding.

border line between "densener" and "chill" is very fine, and the foundryman who uses a densener that is just a little too heavy for the class of iron being poured very soon finds himself in trouble with the machine shop owing to the appearance of hard spots and patches.

The next development in improving the wear of cast iron was by the use of alloying elements, particularly nickel and chromium. These alloys have two main effects when used in small quantities and in the correct proportions:—(1) They raise the hardness of the steel groundwork and

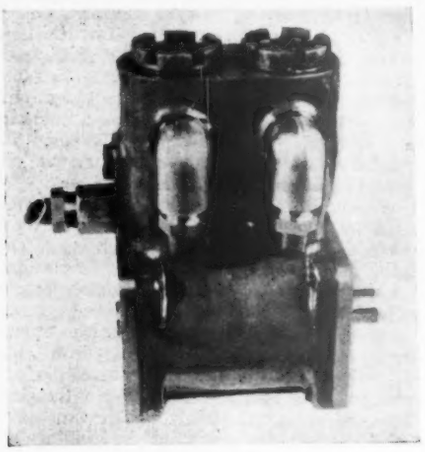

FIG. 1.—VALVE GEAR FOR HYDRAULIC SAWING MACHINE, CAST IN "NI-TENSYL."

thus give extra resistance to wear, and (2) they even-up the structure of the casting so that it is possible to use an iron which is initially harder without the risk of the formation of hard spots in the thinner sections.

The use of these irons (Ni 1.0 to 2.0 per cent., Cr 0.3 to 0.6 per cent.) certainly improves the wear resistance of the iron considerably, but the objection to their use is in their cost, which becomes a major factor for large castings. It is not possible to alloy just one part of the casting, such as the shears of a lathe bed, without alloying the whole of the casting, and the cost is proportionately high. Therefore, for large castings, it is usually sufficient to have a very high-grade unalloyed iron, densened where

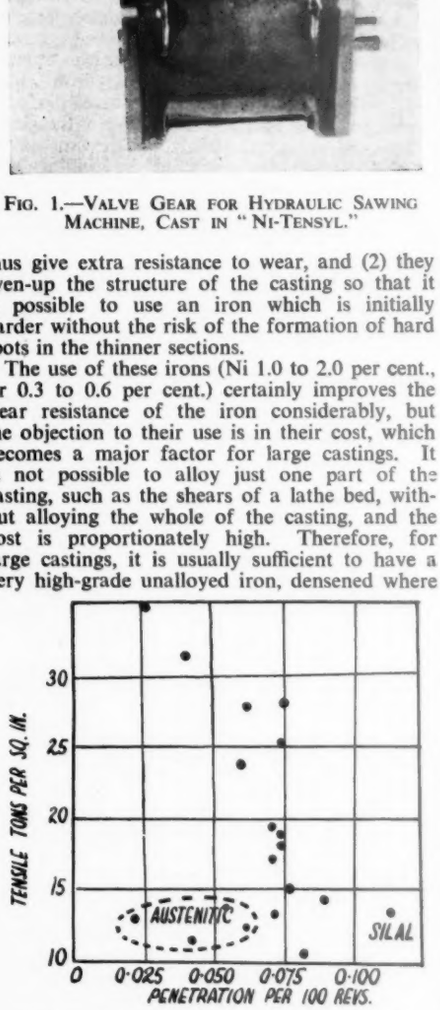

FIG. 3.—TENSILE STRENGTH OF CAST IRON RELATED TO DRILL PENETRATION.

necessary, and reserve the use of alloys for the smaller components, where the benefits can be better set off against the costs. It is well known that some manufacturers make a great point of the use of nickel cast iron in their machine-tool beds, and in cases of machines for very high speeds and frequencies of operations the cost is certainly justified. It is claimed[1] that the extra costs can be offset by the reduced sections and sizes made possible by the use of stronger materials, but the necessity for rigidity and absence of vibration prevents full use being made of this, and sheer weight is often an important factor.

In the field of special and highly-stressed parts alloy cast irons offer enormous opportunities. Irons are available with strengths approaching that of mild steel (Ni-Tensyl is guaranteed to have a minimum tensile strength of 22 tons per sq. in.), and if heat-treated they become as strong as mild steel whilst retaining the characteristics of rigidity, ease of casting, self-lubrication, etc., associated with cast iron. It is important to remember that owing to the presence of graphite flakes, these irons have practically no ductility.

For wear resistance, alloy cast irons are even more useful, particularly for cams. An ordinary alloy iron (Ni 1.5, Cr 0.5 per cent.) is very good, but the use of slightly higher nickel (2 to 3 per cent.) combined with hardening and tempering produces an excellent material. Such irons are machinable with a Brinell hardness of 250 to 300 as-cast, even with ordinary milling cutters, and can be oil-quenched from 850 deg. C. with little variation of size to give a final hardness of 350 to 450 after tempering. In this condition the castings may have to be ground, but the "shift" on hardening is frequently so small that grinding after hardening is unnecessary. The use of nickel improves the uniformity of hardness throughout the casting.

Other uses of alloy cast irons include gears, clutch plates, gibs, tool slides, etc.

Hydraulically-Operated Machines

The development in the use of hydraulic power for the operation of machine tools has created a demand for castings which are pressure-tight at very high pressures, in spite of very intricate shapes and rapidly changing sections. The use of alloy irons with their uniform sections, small graphite, and high strength is very frequently essential. Ni-Tensyl is particularly valuable, and is used for valve control gear and hydraulic cylinders. Fig. 1 shows the valve gear and Fig. 2 shows a group of cylinders for hydraulically-operated sawing machines, tested to 1,400 lbs. per sq. in. without any leakage.

TABLE II.—*Flame-Hardening Experiments on Machine-Tool Cast Irons.*

Bars 2 in. sq. treated by Shorter process.

Material.	Original hardness. Brinell 3,000/10.	Final hardness.		
		Brinell 3,000/10.	Vickers Diamond.	Rockwell C.
Normal machine-tool iron ..	190	269	437	42
Special machine-tool iron ..	192	363	491	44
1.5 nickel, 0.5 chrome iron ..	250	358	476	49
2.9 nickel, 0.9 chrome iron ..	280	388	506	45

Other methods of improving the "ways" of machine-tool beds are constantly being tried out. Hardened wearing plates attached to the beds have been tried but gave great difficulty in obtaining the necessary rigid attachment. The latest development which is interesting manufacturers is the local hardening of the "ways" by flame hardening. This process was developed in this country by Mr. Shorter and "Shorterised" products are well known, but the adaption of this process to cast iron and particularly large castings such as lathe beds is quite recent. A good machine-tool iron is suitable, provided that the combined carbon (that is the carbon content of the steel groundwork) is at least 0.6 per cent., whilst certain manufacturers claim that the presence of 1 to 1½ per cent. nickel is desirable. This is because nickel lowers the hardening temperature, thus rendering the treatment less drastic.

Experiments by the author, given in Table II, and carried out in conjunction with the Shorter Process Company, show that a first-class machine-tool iron of the 18 tons tensile grade gives results almost equal to the nickel cast iron. These bars were ground to 2 in. exact thickness and cleaned up after hardening to not less than 1/1,000 under 2 in. The method of hardening is described by P. A. Abe,[2] who recommends

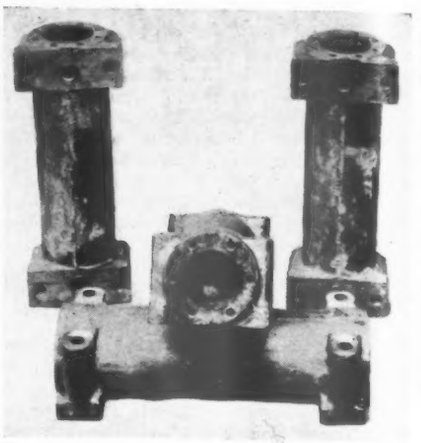

FIG. 2.—NI-TENSYL CYLINDERS FOR HYDRAULIC SAWING MACHINES.

a nickel cast iron, and whilst the author's experiments (carried out on test-bars only) indicate that this is not necessary to obtain the requisite hardness, it is probably correct that the lower hardening temperature and general improvement in hardening properties due to the presence of nickel make the use of nickel cast iron desirable. It would be interesting to compare a series of tests carried out on plain and alloyed irons, working at different speeds of traverse of flame and quench.

Machining Cast Iron

To measure machinability is nearly as difficult as measuring wear resistance. The author has carried out certain experiments which will

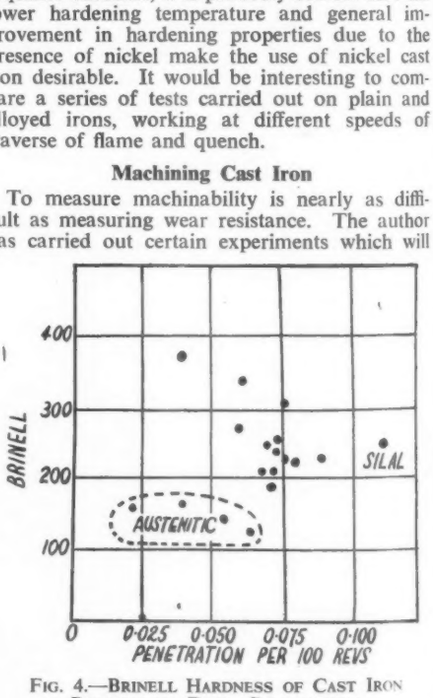

FIG. 4.—BRINELL HARDNESS OF CAST IRON RELATED TO DRILL PENETRATION.

be dealt with later, but unfortunately these were not finished owing to the outbreak of war. Certain results appeared unusual and required repeat tests.

Before the advent of high-speed tool steel, the universal demand was for cast iron that would machine with absolute freedom, and the other properties of cast iron, when used for purposes involving any considerable machining, were entirely secondary, except in hydraulic work. The improvements that have been made

in cast iron would not have been possible without the improvements that have been made in cutting tools.

Thus it is found that as cast iron improved in strength and hardness, so cutting tools became available that would deal with them. With the introduction of tungsten-carbide tools no iron can really be called unmachinable. A white martensitic cast iron with a Brinell hardness of over 500 can be machined with the appropriate tool at 40 ft. per min. Mr. H. H. Beeny, of Alfred Herbert, Limited, has carried out a good deal of work on this subject and results of his researches have recently been published.[1]

Personal observations largely confirm his conclusions except in respect to the statement that tensile strength is the main guide to machinability, and particularly is this so when cutting the modern inoculated irons such as Ni-Tensyl. With these it is possible to use just the same cutting speeds as are used for good-quality irons although the tensile strength is 50 per cent. greater. For cutting Ni-Tensyl, speeds of 150 ft. per min. with a cut $\frac{1}{4}$ in. wide and a feed of 1/48 in. are regularly used, whilst finishing speeds can be taken up to 290 ft. per min. with a 1/96 in. feed. When using these high cutting speeds, the use of a machine tool that is rigid enough to stand up to the job is essential, and the figures given presume that such tools are available.

Undoubtedly the best cast iron for cutting is an annealed iron, and where the strength of the casting is not important this material is the best from a production point of view. One of the most difficult problems in machining cast iron is milling, as tipped tools are not in frequent use. The speed of cut should be very closely controlled.

Other Types of Iron

Some reference should be made to certain types of cast iron which have to be tooled but which have not been mentioned hitherto, as they are not used in machine-tool production. One of these types is represented by the austenitic irons, which demand very much slower cutting speeds and have the disadvantage of work-hardening as machining progresses. Cutting speeds for these should not exceed 80 ft. per min. and heavy cuts are preferred to light cuts. The castings should be annealed if they are under $\frac{1}{2}$ in. thick, and this annealing should be followed by quick cooling, preferably quenching in oil, to obtain a fully austenitic, and therefore machinable, structure.

"Silal," a special heat-resisting cast iron, is very easy to machine owing to the complete absence of pearlite, except that it has a tendency to chill on thin corners. A normal anneal quickly restores full machinability. "Ni-Hard," an iron with martensitic structure, in which the background is the same as that of a fully-hardened steel, is best ground, but as indicated above it can be machined with tungsten-carbide tools at very slow speeds. This has a limited use in machine tools, sometimes being used for centreless grinder rests.

A series of tests covering a wide range of cast irons has been carried out using the tungsten-carbide-tipped drill-testing machine as used by Mr. Beeny. Some of these results are given in Table I. As previously indicated, the results are not absolutely final. The figure for relative machinability is the depth of penetration of the drill per 100 revs. using a slow spiral drill, $\frac{1}{4}$ in. dia., under a load of 51 lbs. These results are plotted against tensile strength in Fig. 3 and against Brinell hardness in Fig. 4. They show that neither tensile strength nor Brinell hardness is a true guide to machinability. The results for "Silal" are comparable with the machinability of annealed cast iron, except that the Brinell hardness would be about 160. The austenitic group cannot, of course, be considered with the others. This bears out a fact which is not sufficiently appreciated—that Brinell hardness only gives comparison of properties of similar materials.

Hard Spots

Finally, occasional difficulties are experienced by engineers owing to hardness and unmachinability. It is germane to point out that in his endeavour to obtain the optimum properties from cast iron the ironfounder has to make his iron as hard as possible for the section concerned. If the iron is slightly harder than expected, owing to some irregularity in the working of his melting plant, or to a quicker cooling rate than expected owing to an isolated thin part or some extraneous cause, then free carbides appear and give machining troubles.

In conclusion, the author wishes to thank Alfred Herbert, Limited, for carrying out the machinability tests; the Shorter Process, Limited, for treating the flame-hardening samples; the British Cast Iron Research Association for performing the impact tests, and the Mond Nickel Company and others for loan of slides.

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Electrolytic Preparation of Micro-Specimens

G. E. Pellisier, Harold Markus and Robert F. Mehl, in the course of an article in "Metal Progress," state that it has been reported that electrolytic polishing may be substituted for ordinary metallographic polishing of iron and steel with excellent results, and with a very large saving in the time required for the preparation of samples for microscopic examination. It may be said, they state, that all of the claims made for the method have been confirmed. The methods used in preparing the specimens are those recommended by the originators and tabulated below; the apparatus is shown in Fig. 1 and is simple and easy to assemble. Briefly, all samples were ground and then rubbed on emery paper to and including the 000 paper, and then polished electrolytically. The recommended electrolyte of acetic anhydride, perchloric acid, and water was used, with temperatures below 30 deg. C. (85 deg. F.). The space between electrode and sample was $\frac{1}{4}$ in. to 1 in.; the area of the aluminium cathode was approximately 20 times the surface area of the specimen.

Adjustment of current density appears to be the most important item in the technique; at too low a density, deep and objectionable etching occurs, and at too high a current density gas is evolved at the specimen and causes uneven polishing. Current density is satisfactory when upon changing the cell voltage no appreciable change in current density occurs. Mounting of specimens is unnecessary—organic or synthetic mounting materials such as bakelite should not be used owing to the danger in the reaction between such materials and perchloric acid. Details of electrolyte composition, current density, and cathode material are tabulated below. It is found that electrolytic polishing of steel under these conditions requires about 10 min.

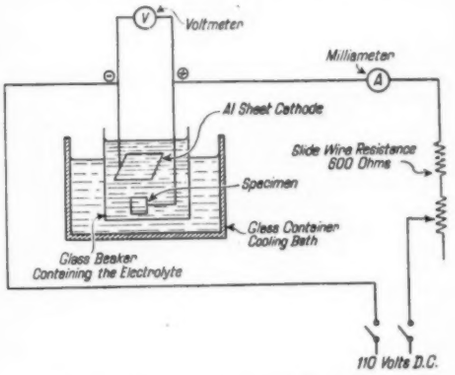


FIG. 1.—ARRANGEMENT OF THE APPARATUS.

Surfaces prepared in this manner, after etching with ordinary reagents, are quite satisfactory for microscopic examination and photography at all magnifications. Compared with the difficulty of polishing on wheels, very little skill is required for the preparation of satisfactory surfaces. These surfaces do show some undulation, but this is on too gross a scale to be troublesome even at magnifications below 100 diameters. Since electrolysis seems to remove protruding ridges between the 000 scratches, it may appear surprising that specimens may be more readily polished to an edge than with the ordinary polishing procedure. Flat surfaces on large specimens are much more readily prepared. The electrolytic method appears to have special advantages for the study of inclusions, for these are obviously not ground flat during electrolytic polishing, but retain the same shape as within the body of the steel.

Metal.	Solution.	C.D.*	Voltage.	Temp. deg. C.	Time min.	Remarks.
All carbon steels, martensitic, pearlitic, and sorbitic; Armco and white cast iron; 3 per cent. silicon steel	Acetic anhydride, 765 cc. Perchloric acid, 185 cc. sp. gr. 1.61 (65 per cent.) Distilled water, 50 cc. 0.5 per cent. Al	4 to 6	50†	<30	4 to 5	Prepare solution 24 hrs. before using. Use moderate agitation. Al increases viscosity which permits more vigorous agitation and current density of 3. Can use at current density of 10 for austenitic steels. Prepare samples to 000 paper. Fe or Al cathode.
Austenitic steels	Acetic anhydride, Perchloric acid (65 per cent.) 2 parts to 1 part	6	50†	<30	4 to 5	Same as above.
Iron and silicon-iron	Orthophosphoric acid sp. gr. 1.316.	0.6	0.75 to 2.0	—	—	Iron cathode.

* Current density in amps. per sq. decimeter. † External applied voltage.

Book Review

Soldering, Brazing and the Joining of Metals. By Thomas Bolas. Revised and enlarged edition. Published by Percival Marshall & Company, Limited, 60, Kingsway, London, W.C.2. Price 1s. 6d. net.

This elementary handbook is primarily written for the amateur mechanic. It would also usefully serve for evening-class work in technical schools. The paragraphs on soldering and welding aluminium are now out of date, as these operations can be done reasonably effectively, yet as the book is for the amateur, possibly the advice given is satisfactory. Quite a large field has been covered in the eleven chapters.

Ironfoundry Practice, 1919-1939*

By VINCENT C. FAULKNER, F.R.S.A.

It is thought that by reviewing the progress achieved in the foundry industry since the end of the last war, it should be possible to indicate to a rising generation of engineers the potentialities afforded as a field for future activity. Moreover, it will be revealed that during these two decades a number of new alloys have been developed which are of such importance that they cannot be ignored by any machine designer worthy of the name.

It is presumed that the young engineer is conversant with the fundamental principles of castings production but that he needs reminding that castings not only provide the raw materials for every type of engineering but also are an essential part of the building industry. Externally, the modern West End hotel will carry 600 tons of castings in the form of gutters, fall pipes and the connections to the main sewers. Internally, such buildings consume enormous numbers of castings in the form of baths, radiators, grates and ranges.

Progress has been registered in every section of the industry, including (*a*) buildings; (*b*) raw materials handling; (*c*) process handling, admitting of many sub-divisions; (*d*) melting; (*e*) cleaning; (*f*) moulding machinery; (*g*) moulding materials.

Foundry Buildings

Only recently has any real study been made of the problem of housing foundry plant and processes adequately. So far, it is assumed that a rectangular steel-frame structure carrying as walls 6 or 7 ft. of brickwork, then glass and finally either bitumen-covered corrugated sheeting or asbestos, satisfies the main conditions provided that it is of adequate height and properly positioned with reference to transport and the sun.

Although such structures usually, though not always, allow for easy extensions, the writer is not quite convinced that finality has been reached. He recollects visiting a Yorkshire foundry, the design of which was so complicated that it was difficult to carry away a mental picture of its lay-out, yet, though like Topsy "it growed up," the management asserted that considered from no matter what angle it answered all demands placed upon it perfectly. The next day, he inspected a modern ironfoundry of the rectangular type, where he was assured by the manager that somehow or other the building was a misfit. In Copenhagen there is a circular foundry in which all external and some internal transport is effected by barges on a system of canals. Thus the precept of the rectangular foundry should not necessarily be accepted as axiomatic.

External Transport

Generally speaking, the position in 1919 for dealing with the raw materials by any up-to-date plant was as follows:—

Pig-iron and Scrap.—The wagons arriving on a siding parallel to the long side of the foundry wall were unloaded by hand, and the contents were thrown into stock bins. From these bins, iron wheel-barrows were used to transfer the load by means of a hoist to the cupola stage. Here, often, were smaller bins from which again barrowloads were weighed by passing over a platform weighbridge. The contents were spilled near the cupola charging hole and finally thrown or shovelled into the furnace.

Coke.—Much the same procedure took place with coke, except that weighing was often omitted as being less reliable than measuring because of water absorption.

Sands.—It was good practice, and still is, where relatively small quantities of sands have to be handled, to shovel them direct from the wagon or lorry through a shutter-closed opening in the foundry wall to fill an appropriate bin.

Current Transport Practice

For handling large quantities, one of many good methods is to unload the wagons by a magnet suspended from a crane, either overhead traveller or jib, into sleeper-lined bins. In front of these run specially-designed cylindrical skips mounted on a scale car running on a light railway. Into these skips are weighed out to the metallurgist's orders the various raw materials necessary to constitute one charge for the furnace. The end of the light railway is looped and over this loop is the charging machine. The hook from the machine is attached to the skip and the charging machine then elevates its load, racks out, lowers the casing of the cylinder to rest upon a horseshoe-shaped flange within the cupola, and then by lowering a little further the cone-shaped base of the skip leaves the cylinder to release the charge. The return motions place the skip or charging bucket back on to the scale car to continue its journey back by a second loop to receive a further charge.

A system well suited to a smaller type of foundry is to have the stockyard spanned by a ground-level-operated overhead crane. The skips are filled with the individual raw materials and elevated to just above charging-stage level and then racked out to a position portioned off along the edge of the cupola stage for the reception of the corresponding raw material. Above these bins and positioned outwardly is a rail, and by lowering into the void between the top edge of the bin and this rail, the contents of the skip are emptied, as the back edge of the bottom of the skip carries a flange whilst the front is open.

The line of bins on the platform is spanned by a monorail from which is suspended a spring dial and beneath that a tilting bucket. The various ingredients are weighed into this and then the bucket is pushed along the monorail pathway which passes in front of the cupola charging hole. Here the contents of the buckets are emptied down a chute into the furnace.

It is nowadays by no means unusual to house the raw materials storage within the main foundry building by bringing in railway sidings. It has proved distinctly advantageous during war lighting restrictions. When this is done, use is made of scale cars and the system described earlier may be used; but in other cases a charging machine of the inclined plane is preferred. It is transportable so that it can serve two furnaces on alternate days. The inclined plane takes special loading boxes which, reaching the end of the ramp, automatically tilt. In order to protect the back wall, it is desirable to insert a baffle plate to break the fall.

Modern Sand Handling

The sand will arrive on a siding laid against and parallel to the foundry wall, from which is thrown out a roof to afford some protection from rain and wind. The sand is handled either by monorail-suspended grab buckets or manually to fill louvre-fronted bins through shuttered openings. The louvres are loose boards set in slots at an angle of 45 deg. This simple system conserves space, creates tidiness, increases the capacity of the bin and allows arching troubles to be easily overcome. Very large foundries will provide means for emptying the wagons either by their complete rotation in cradles or high angle tipping.

Moulding Machines

In 1919 there were plenty of good moulding machines available but it is doubtful whether they were ever utilised to capacity owing to inadequate handling arrangements. Since the last war new types of moulding machines have made their appearance. In addition to some excellent electrically-operated machines, there are Sandslingers, now firmly established as economic moulding units for many purposes, and the Sandontap system, which is still in course of development. The former is based upon the continuous supply of sand to an impeller head, which discharges its stream at such speeds that moulding boxes placed beneath it are rapidly filled with sand rammed to a suitable density. The Sandontap system functions by a clever utilisation of compressed air to carry a stream of sand through piping which terminates in a vertical but adjustable pipe so that boxes placed beneath it are rapidly filled with rammed sand. Obviously such developments are revolutionising internal transport systems and offer much scope to the foundry engineer for the exercise of his craft.

It is reasonable to state that where specialised moulding plant was provided, many types of castings were produced equally cheaply by hand labour. By allotting a definite area to the production of one type of casting, and arranging for a row or rows of specially-suited box parts, alongside which are piles of sand, the moulder by himself or with a mate or an apprentice will carry his pattern from box to box, making each mould in sequence. After casting up, he strips the castings and prepares the sand for the next day's work. By such a procedure human movement is limited and rational. Quite often the installation of a moulding machine, *per se*, merely converts the moulder from a sand puncher into a sand shoveller and porter.

The recognition of this fact saw the birth of the mechanised foundry, and with it, perhaps for the first time in industrial history, the real co-operation of the engineer. The problems to be solved reduced to their simplest dimensions were:—

(1) The moulding machines must be supplied continuously with a stream of *suitable* sand.

(2) The completed moulds must be removed from the moulding machine expeditiously.

(3) The boxes, if such are to be used, must be returned to the machine quickly.

(4) As an unlimited supply of sand and boxes is not an economic possibility, the moulds must be cast up as quickly as possible, involving a continuous supply of liquid metal.

Sand and Its Handling

In condition (1) of the problem, the word "suitable" has been italicised. In 1929, sands were "lean" and "fat," "coarse" and "fine," and it was evident that for their control numerical evaluation was essential, and much credit in this field must go to the American Foundrymen's Association for their pioneer work. For control purposes practice has proved that adherence to specified figures for moisture content, permeability and compression strength is all that is necessary. To ensure regular properties in moulding sand a mass of complicated plant has to be installed. Because of its abrasive nature and its potential stickiness, sand is a difficult material to handle.

After fulfilling the essential requirement that all moulds must be knocked out in one or at least a limited number of places, the sand must

*Abstract of an address delivered to the Manchester Association of Engineers (Junior Section), Mr. T. Makemson presiding.

be freed as quickly as possible from tramp iron. As belt conveyors are certain to be incorporated somewhere in the system, sharp scrap can cut them to pieces. If the sand arriving at the knock-out were all of the same type, the engineers could adopt a standardised process, but a factor of fundamental importance is the ratio of metal to sand and the amount of coring. If the ratio be high, the sand will be hot and dusty and the knock-out a most unpleasant place at which to work. A low ratio of metal to sand is obviously an easier proposition, the sand then being cooler and relatively dust-free.

The engineering problems to be solved at the knock-out in the case where the sand is hot and much dust is present involve consideration of the following:—

(1) Width of spacing and the size of the bars of any grating provided.
(2) Should the grating be jarred by the action of a cam?
(3) Should the boxes be returned to the moulding machines by floor transport, pendulum conveyor, roller pathway, or by the mould conveyor (usually a continuous series of contiguous tables attached on the underside to a moving chain or runner on roller wheels)?
(4) Should the dust be extracted upwards or downwards?
(5) How can the dust-extraction system be designed so as to give reasonable working conditions without removing the valuable ingredients of the sand, such as coal dust?
(6) Can a structure be built around the knock-out so as to limit the area to be considered?

Here indeed is work for the engineer, undreamt of during the last war.

The next problem is to transfer the sand, freed from the castings and the larger pieces of tramp iron by the grating, to a sand reconditioning plant. By an apron conveyor or other means the sand is fed into some form of sieve. Here again the engineer has a fairly wide choice. It may take the form of an electrically-vibrated screen or series of screens, a mechanically-vibrated sieve, a rotating cylindrical or octagonal sieve, all installed at a fairly acute angle to the horizontal to give a forward motion. The rotating sieves are often preceded by an extension carrying internal vanes to break up any hard pieces of core. It is usually unnecessary to make anything but the most elementary provisions for the removal of the material rejected by the sieves, but special cases do exist. Some foundrymen deem that silt in moulding sand is injurious, so by installing a nest of electrically-vibrated sieves only the sand retained on the centre one will be re-used, and means will have to be provided for taking away the fines.

The reclamation of core sand is a comparatively new development, and its importance can best be stressed by recalling that one foundry for many years removed no less than 90 tons a week. A recent practice is to cascade the sand down an inclined plane through which at intervals there is an aspiration of air which effectually removes the fines.

Returning again to moulding sand, which has been sieved in a mechanised moulding plant, it is now passed beneath an electro-magnet to free the sand from metallic impurities, following which the real process of reconditioning begins. For transferring to the reconditioning plant there is a choice between a belt and bucket elevator, a belt conveyor, and a belt-fed line of suspended contiguous buckets. Present day favours the belt conveyor, if space be available. It is at this stage that the designer has to take into consideration the following factors. The foundry desires that advantage should be taken of this journey (1) to cool the sand as much as possible, (2) to incorporate new sand, coal-dust and other materials, (3) roughly to regulate the moisture content, and (4) to return to the system any sand surplus to the capacity of the hoppers serving the moulding machines. Unless these problems are solved in the original lay-out, endless improvisations will have to be made, and improvisations have been the bugbear of the foundry industry since the time of Tubal Cain.

Most plants, though not all, allow the cleaned sand to be spilt from the conveyor into one or more storage hoppers. It is usual to close the base of these with a rotating plate which allows predetermined quantities to be ploughed off into one or more sand mills. Here there is a choice of two continuous types and a number of batch types. There is a body of opinion which believes that better control can be given by the batch type mixer. At least it may allow a quantity of defective castings to be correlated with certain mixings rather than a period. The predominant factor, however, is the type of casting being made.

With a continuous sand-preparing mill, the feed will be direct from the rotating plate of the sand storage hopper, whilst for the batch mixing the mill is filled by means of a bucket-loader running up an inclined plane and tilting at the end of its journey. The batch-type mill is often designed with a disintegrator as an attachment. There are a number of types of disintegrators available, which vary in method from sending the sand at high speed through a number of loosely-suspended iron bars, to passing the sand through a rotating cage consisting of an inner cage rotating at high speed and an outer stationary one, each constructed from round steel bars.

Distribution of Prepared Sand

This problem is indeed an interesting one, and involves several factors: The sand, now possessing specified properties as to moisture, permeability and compression strength, must not have these properties jeopardised by the time factor or methods of handling; thus, rate of consumption must be considered.

In a continuous casting shop it is usual, but by no means invariably so, to place the moulding machines in one or more lines running the length of the shop. Where casting is intermittent, as in the case of most steel foundries, the machines may be placed against the wall. Dealing with this situation first, it is quite a good system to instal a gangway beneath the crane rails, wide enough for the sand to be barrowed along it to fill hoppers situated above the moulding machines. Again, for a large jobbing shop it is both sensible and economical to instal a belt conveyor provided with ploughs which can be set to feed, by a short secondary conveyor, one or more travelling Sandslingers capable of serving a whole moulding floor. This system, operated in conjunction with a grating running the length of the shop, beneath which is a belt conveyor for returning the sand to the reconditioning plant, provides a rational means of solving the mechanisation of the jobbing foundry.

For many continuous casting plants the sand leaving the mill is elevated by means of a belt and bucket system to the height necessary for filling the moulding machine hoppers. Experience has shown that the design of these elevators should incorporate the following points: (1) They should be enclosed in steel plating so as to create a chimney effect to aid cooling. (2) The drive and the tensioning device should be installed at the top to facilitate maintenance. (3) Preference should be given to the use of small buckets associated with high speed—something of the order of 200 ft. per min. The centrifugal action resulting from such a speed minimises the adherence of the sand.

For the feeding of a line of moulding machines, there is a choice between ploughing from a belt conveyor to the hoppers placed above each machine, or a scraper flight (push-plate) conveyor. Both have their advantages and drawbacks, but at the moment the designers favour the push-plate type, as no labour is required for the adjustment of the ploughs, and by serrating or weighting the edges of some of the scrapers a clean pathway free from balls of sand can be achieved.

Moulding Machine Hoppers

In the early stages, trouble was encountered through sand sticking or hoppers failing to be filled. The operators soon learnt to remedy matters temporarily by bestowing a resounding hit with the nearest iron bar. Denting occurred, which aggravated the trouble. Most hoppers now carry two adjacent sides parallel and two slightly tapered. Whilst the use of stainless steel, the internal application of blacking and other means have been proposed, the final solution is complete emptying of the hoppers every week-end and thorough cleaning.

The closure of the hoppers is usually of the clam-shell variety, and attention is being given to adjusting the supply of sand emitted at each opening. The complete solution of this problem would have a serious economic result, for in many plants the excess fall is so great that the moulding machines are surrounded by a grating beneath which runs a belt conveyor for returning the spilt sand back to the system.

Mould Handling

The problem ranges from the simple one of the boxless mould, which merely requires weighting, to the very difficult one of making a motor-car cylinder block demanding the insertion of many cores, gauging the correctness of their setting, closing, and then passing along to the teeming station. Reasonably to effect this, there must be installed a line of pendulum conveyors from the core shops, and a gang of men at work, each of whom sets one core or a small group of them, whilst the mould conveyor is in motion. Problems of synchronisation arise demanding the serious attention of the engineer. Where coring is not such a heavy proposition, the moulds can be filled with cores whilst resting on a short length of roller pathway connecting the moulding machine with the conveyor. For casting up the moulds, either hand shanks or monorail suspended ladles are used.

Removal of Castings

The major problems involved where large quantities of castings are produced at one position are:—(1) The concentration of heat in one spot would render the shop very uncomfortable; (2) the castings would be subjected to auto-annealing. These problems are solved by (1) rapidly wheeling the castings away in steel containers by hand or auto-truck, (2) the installation of an apron conveyor to feed the fettling shop, or (3) suspension from an overhead chain conveyor, which will take the castings into the open air, and may cover a total distance of half a mile. The Ford engineers have made use of such a conveyor for the additional purpose of the automatic return and sorting of the various types of scrap into the proper stock bins, as the conveyor in its journey passes over the scrap yards.

Core Making

The improvements shown in this department since the last war are particularly noteworthy and embrace:—

Core-making Machinery.—There is now available a number of types of machines known as core blowers, which virtually fill core boxes instantaneously, limiting the core maker's work to the clamping of the box on to the machine and stripping the rammed core on to a plate for carrying it away to be dried.

Core-Sand Mixing Machines.—In addition to the horizontal paddle machine of the type used by bakers for mixing dough, which was available during the last war, there is now a vertical model giving unquestioned satisfaction. The well-known "sausage" machine has also been improved to machine-tool standard.

Drying Ovens.—For large outputs, the batch type of oven has given way to continuous stoves. Here a choice is had between two methods. The better one from a handling point of view is to allow a continuous line of pendulum conveyor to circulate so as to serve the core makers, and to pass through a horizontally-disposed oven, past the inspection and blacking to a second stove for drying after this operation, and then to the mould assembly and finally back to the core makers. A second system is to send the cores down to a two-chambered vertical oven, the interior of which carries a series of suspended trays, by means of a roller pathway, a steel band, or a pendulum conveyor. In this case, labour is required for filling and emptying the ovens, and once again for a similar handling into the blacking stoves.

A good system for providing the core makers with sand is to install the mixing department on the first floor and to spill the mixed sand down a shute, the end of which terminates a few inches above the centre of a circular table, around which the core makers work. Failing this, recourse can be had either to a line of tilting buckets or to the use of wheeled containers placed by the side of each core maker.

Fettling

Great progress has been made since the last war in the cleaning of castings. The major improvements have been:—

Transport.—For the smaller castings extensive use is made of trays pushed along roller pathways installed at waist height.

Hygiene.—All grinding machines are now by law fitted with dust-removal apparatus, whilst tumbling barrels must also be similarly cared for or else be installed well away from working positions.

Sand Blast.—Sand blast as such has given way to shot blasting in order to minimise the risk of silicosis. New machines which mechanically, instead of pneumatically, propel shot on to the surface of castings have been devised, and many installations have been made.

Grinding.—High-speed machines allowing practically the whole of the wheel to be used whilst maintaining reasonably constant speeds are now current practice.

Melting

The position at the end of the last war was that iron was melted either in the cupola or the air furnace, whilst steel was made in all the classic furnaces. Since that time, the following developments have been registered.

The foundry cupola has been improved so that it can now yield iron of more regular composition at a higher temperature with a smaller fuel consumption. New methods of melting include the oil or pulverised fuel-fired rotary furnace and various types of electric furnaces. The demand for the newer and better types of cast iron warrants such improvements.

It seems germane to remark that at the beginning of the period under discussion there was not available to the foundry industry a lip teeming ladle which could honestly be designated an engineering job.

What a Foundry Makes—Now and Then

Students in 1914 were taught that grey cast iron was a material possessing at the worst 8 tons per sq. in. tensile, intermediately 10 tons, and at the best 12 to 14 tons. During the war, an improvement was made by adding a modicum of steel, and 14 tons could be relied upon. The engineers did realise, however, that cast iron was rigid and strong in compression, but the bogey of tensile was still uppermost in their minds. To-day, if they still pin their faith to high tensile strength, though in practice it is very seldom necessary, the specialised foundry will provide material of 20 or even 35 tons tensile.

This progress is obviously significant, but concurrently with it there have been developed ranges of heat-resisting and corrosion-resisting irons. Many of the former allow the engineer cheaply to replace much more expensive materials, whilst the latter will often permit cast iron to be used instead of gunmetal. Again, because cast iron contains within its make-up a certain amount of graphite, it possesses excellent wearing properties, and engineers would be unwise not to use it for machine tools where sliding surfaces are involved. A further valuable feature of the graphite constituent is the power which it confers upon the mass of damping down stresses and preventing their aggregation at one point—a normal prelude to fracture.

As the evaluation of the property of abrasion resistance is not easy owing to such questions as whether or not a lubricant should be used during the test, the only useful figures that can be given are comparative lives on well-known jobs. There is now abundant evidence to show that specially hard cast irons will outlast manganese steel for cement crushers, mild steel for pan mill bottoms, and drop forgings for impeller heads. It would require a special lecture to detail the properties of the dozens of special irons now available to the engineer, but just as he realises that the provision of special steel for dies, cutting tools, files, drills and so forth is a distinctive branch of the steel industry, now he must be cognisant that there has arisen a similar section in the ironfoundry industry well capable of providing the engineer with complex shapes made in materials having a really exceptionally wide range of all sorts of high-duty properties.

In steel castings, similar developments have been made and the position to-day is such that engineering components which have to resist alternating stress can, with equal or greater safety, be made as steel castings instead of as forgings. The Ford cast crankshaft, which is a cross between iron and steel, typifies such developments. Again, a cast steel crankshaft, made in an Australian foundry to replace one of German origin which fractured in service, was so successful that it carried the ship safely from New South Wales to England, despite the fact that a second forged shaft broke during the voyage. Recent attempts to replace high-pressure, high-temperature valve castings by steel forgings have been unsuccessful.

Conclusion

The object of the Paper has been twofold. An attempt has been made to show how, since the intelligent co-operation of the engineer has been obtained, the foundry industry has responded by providing him with extremely cheap components of impeccable dimensional accuracy, excellent machining properties and improved mechanical properties. The second object has been to show that the properties of the new cast irons are such that he can with confidence extend the range of his demands upon the resources of the foundry industry and by so doing lighten the weight and lower the cost of the products of his designs. Incidentally, an opportunity has been provided to the writer of indicating to the young engineer the potentialities which the foundry industry has as a field for his future activities.

Iron and Steel Institute

The annual meeting of the Iron and Steel Institute will be held in London on May 2 and 3, circumstances permitting.

Cylinder Wear

The wear-resistance properties of grey cast iron at various temperatures are usually good, with the result that cast iron is widely used by engineers for parts which have to withstand excessive wear, and among such parts are cylinder liners for steam and oil engines. In the use of cast iron for internal-combustion engines many problems have arisen with regard to wear, and investigations have been carried out for some years in the laboratories of the Institution of Automobile Engineers, and in the works of members of this Institution, with a view to elucidating such problems.

The progress of the work has been reviewed in a series of reports published at various intervals. These reports have dealt with a discussion on published information, experiments on cylinder wear, a summary of replies and views submitted by a representative selection of manufacturers and operators of automobile engines both in 1932 and in 1937, and an investigation dealing with two series of experiments using cylinder liners of various materials under "moderate" and "severe" conditions of service. The whole of these reports have recently been issued in book form, and the researches and investigations thus collected form a very interesting record of the work which has been done. Foundrymen ought to find particular interest in those sections dealing with liner materials.

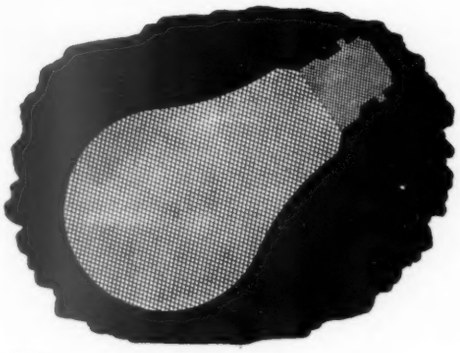
Consideration of these reports show that the progress which has been made in recent years in reducing cylinder wear is due principally to improved liner materials and to the importance of adequate lubrication. The main developments which have taken place as regards materials have been in the use of either austenitic cast-iron liners, liners hardened by heat-treatment, nitrogen-hardened cast-iron liners, or chromium-plated liners. Austenitic liners have been successfully used where abrasion is an important factor, and similar results are obtained with hardened and tempered alloy cast-iron liners. When corrosive conditions are encountered, however, the latter type of materials does not appear to be so satisfactory. Nitrogen-hardened liners give good results in petrol engines, but their suitability for other oil engines has not been definitely established. Under "moderate" test conditions the alloys giving the most satisfactory results are 5 per cent. nickel cast iron, austenitic cast iron, cast iron containing 1 per cent. of copper, nitrided cast iron and chromium-plated iron, while under "severe" test conditions the best results are obtained with austenitic cast iron, cast iron containing either 13 per cent. or 32 per cent. of chromium, and chromium-plated iron.

Heavy Nickel Plating

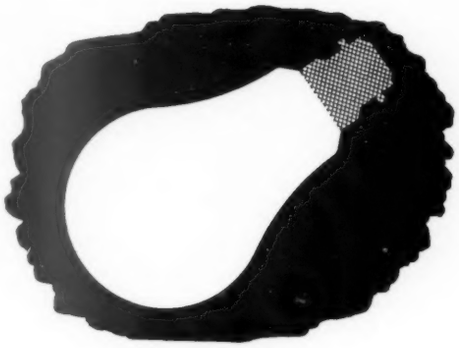
Mr. L. Weisberg, speaking at a meeting of the Philadelphia Branch of the American Electroplaters' Society, said that nickel deposits for wear- or corrosion-resisting purposes were of the order of 0.005 in. in thickness, and deposits as thick as 0.2 in. could be made in order to restore worn parts to normal size.

Porosity, he said, was a pressing problem, so far as thin deposits were concerned, but it usually disappeared when the thickness approached 0.002 in.; it was seldom found in the thick deposits. Electro-deposited nickel, nowadays, continued the speaker, could be controlled to meet numerous specifications. In electrode-deposited nickel, tensile strengths varying from about 23 tons to 55 tons per sq. in. could be produced. The Brinell hardness could be varied from 125 to 500. After annealing, electro-deposited nickel approached the same physical state as other forms of nickel, and showed a corresponding change in properties.

Improved lighting



improves output



Poor lighting handicaps every type of worker. Skilled men work slower to avoid mistakes, the semi-skilled and learners sometimes make them—and production is held up. Light up then—and get on. Remember that Osram Coiled Coil Lamps will give you up to 20% more light. They're sturdy too, so specify Osram.

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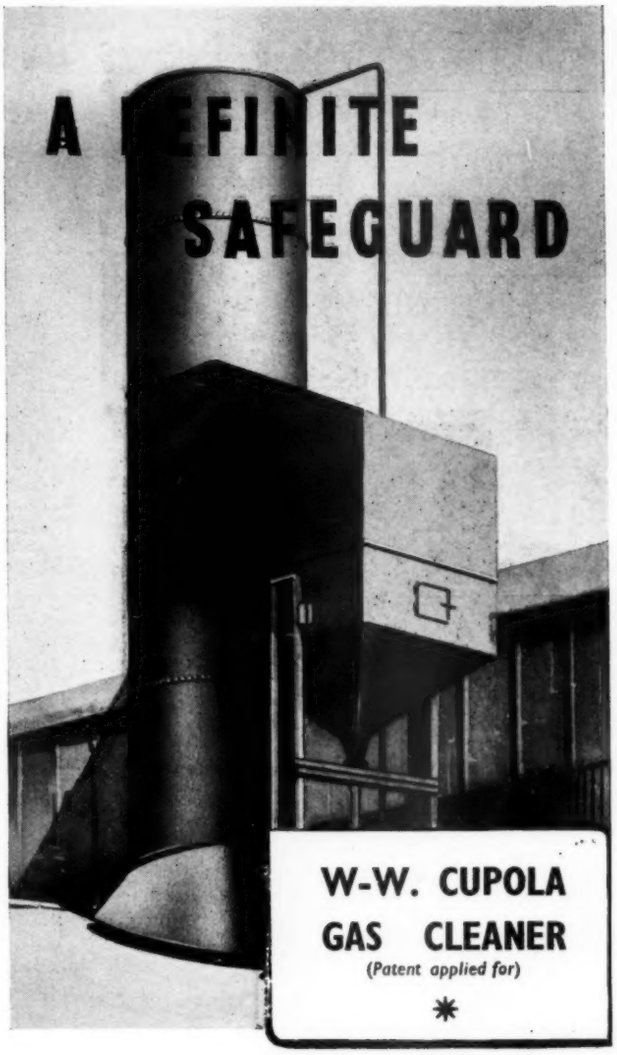

Any foundry may be sure of a clean roof, no fire hazard, no sparks, fewer complaints from neighbours and no furnace glare at night, when the cupola is equipped with the new Whessoe-Whiting Spark Arrestor and Gas Cleaner. In war time the blackout problem is solved and in normal times the economies effected by the equipment make it a necessity for any foundry.

Both first cost and operating costs are low and the Cleaner is of simple construction with renewable liners and no moving parts.

The Whessoe Company will be glad to supply further information regarding the new Whessoe-Whiting Cupola Gas Cleaner. Please state cupola shell diameter when writing.

WHESSOE

Advertisement of The Whessoe Foundry & Engineering Co., Ltd., of Darlington.

The Week's News in Brief

Trade Talk

IN FUTURE all iron and steel imports into Sweden will be under the control of a new organisation, Svenska Importfoereninegn foer Jaernprodukter.

THE SCHEME to build blast furnaces at Norrbotten, Sweden, on which it was hoped to start last December, has been deferred indefinitely owing to the Russo-Finnish conflict.

G. A. HARVEY & COMPANY (LONDON), LIMITED, of Greenwich Metal Works, London, S.E.7, inform us that they have now re-opened their West End offices at 58, Victoria Street, London, S.W.1.

PLANS for the provision of new offices, a canteen and new patternshop at the Hamilton Foundry of the Fullwood Foundry Company, Limited, have been approved by the local Dean of Guild Court.

WOLVERHAMPTON IRON FOUNDERS, LIMITED, is being wound up voluntarily. Mr. Enoch Cox, Berrington Chambers, 93, Tettenhall Road, Wolverhampton, is the liquidator.

THE MINISTRY OF LABOUR has advised employers organisations for the trades engaged in war production that they should arrange to give the normal Easter break to their workpeople.

TUNNELS MADE BY BOULTON at the Soho Foundry, Birmingham, now occupied by W. & T. Avery, Limited, a century and a half ago have a new use. They have become air-raid shelters.

R. A. LISTER & COMPANY, LIMITED, engineers, of Dursley, are to offer the balance of unissued capital in new ordinary shares to existing shareholders. The offer will be made in the proportion of one new share for every 11 held.

THE SPANISH GOVERNMENT are considering the laying of a three-track railway to afford a direct connection between Bilbao and Barcelona to promote the industrial development of the country. It is reported that an all-electric service of trains is contemplated.

THE MINISTER OF SUPPLY has appointed a Departmental Committee "to consider whether an increased production of non-ferrous metallic ores in the United Kingdom is desirable and practicable, and to make recommendations." The members of the Committee are: Sir William Larke, K.B.E. (chairman), Dr. C. G. Cullis, Mr. Arthur Deakin, Mr. J. Stanley Holmes, M.P., and Mr. S. S. Taylor. Prof. J. A. S. Ritson, Mr. T. Eastwood and Dr. M. Macgregor will act as Assessors to the Committee. The Secretary, to whom all communications should be addressed, is Mr. W. C. C. Rose, of the Geological Survey of Great Britain, Exhibition Road, South Kensington, London, S.W.7.

Personal

MR. ASHLEY S. WARD, Master Cutler, a joint managing director of Thos. W. Ward, Limited, Sheffield, has been elected a director of the Park Gate Iron & Steel Company, Limited, Rotherham.

MR. E. BRUCE BALL, managing director of Glenfield & Kennedy, Limited, Kilmarnock, and President of the Institution of Mechanical Engineers, was one of the new Fellows elected at a meeting of the Royal Society of Edinburgh last week.

MR. J. L. HENDERSON has taken up duties under the Board of Trade, which has decided to set up a Press section, which will be concerned, among other matters, with giving information regarding the new export drive for which the Export Council, under Mr. D'Arcy Cooper, is finally responsible. Mr. Henderson has been loaned by the Iron and Steel Controller for the duration of the war to take up this office. It is understood that Mr. Henderson will continue his work in the scrap iron and steel campaign, representing the Board of Trade.

Will

EDESON, ARNOLD, of Sheffield, export manager for Edgar Allen & Company, Limited, steel and tool manufacturers £1,327

Obituary

MR. JOSEPH FAWCETT, a director of Smith & Fawcett, Limited, ironfounders, of Lidget Green, Bradford, has died.

THE DEATH has occurred at Rio de Janeiro of Mr. Frederick A. Smith who was for twelve years a local director of Thos. W. Ward, Limited, of Sheffield. He had been in the service of the company for 44 years.

MR. OLIVER BODEN, managing director of Nuffield Mechanisations & Aero, Limited, and vice-chairman of Morris Motors, Limited, died suddenly on March 6, aged 54. Mr. Boden worked with the Vickers group of companies in the last war.

MR. JOHN GEORGE BROCKBANK, of Edgbaston, whose death is announced at the age of 80, was a well-known Birmingham metal merchant, and for many years was a prominent figure on the Birmingham Exchange. Mr. Brockbank was head of the firm of Carrick & Brockbank, Cannon Street, Birmingham, until his retirement some years ago. During the Great War he gave valuable assistance to the Government in the control of the supply of spelter.

Contracts Open

Chester-le-Street, March 18—Iron and steel for the year ending March 31, 1941, for the Urban District Council. Mr. William Ridley, council surveyor, Council Chambers, Chester-le-Street.

Doncaster, March 18—Ironwork during the year ending March 31, 1941, for the Highways Department. The Borough Surveyor, 2, Priory Place, Doncaster.

Maesteg, March 30—Tools, iron castings, etc., for 12 months from April 1, for the Urban District Council. Mr. Evan Davies, surveyor, Council Offices, Maesteg, Glam.

Bloemfontein, March 29—Deep-well pump heads and engines capable of pumping from a depth of 150 ft., with a capacity of between 1,000 and 1,500 galls. of water per hr., for the Administration of the Orange Free State. (D.O.T. reference: T. 16,837/40.)

Johannesburg, April 22—15-ton electrically-driven Goliath crane, for the South African Railways and Harbours Administration. (D.O.T. reference: T. 16,786/40.)

New Companies

(From the Register compiled by Jordan & Sons, Limited, Company Registration Agents, 116 to 118, Chancery Lane, London, W.C.2.)

Brocklin, Limited, 185, High Street, Smethwick—Capital, £1,000. Ironfounders, etc. Directors: J. C. and J. W. Nicklin, J. T. Brockhouse, and J. W. Nicklin, junr.

Minworth Metals, Limited, Forge Lane, Kingsbury Road, Minworth, Warwickshire—Capital, £20,000. Manufacturers of and dealers in aluminium and other metal alloys, etc.

George Blair & Company, Limited—Capital, £10,000. Iron and steel manufacturers, general metal merchants, etc. Directors: G. Blair, Thistlewood Hall, Wolsingham, Co. Durham; R. and H. Jennings.

Applications for Trade Marks

The following list of applications to register trade marks has been taken from the "Trade Marks Journal":—

"SILVER CIRCLE" (Device)—Hand tools and instruments. GEORGE COHEN SONS & COMPANY, LIMITED, 600, Commercial Road, London, E.14.

"NICHRONAMRON"—Wire, made from alloys of nickel and chromium, for electrical purposes. SCOTT INSULATED WIRE COMPANY, LIMITED, Queensland Works, Westmoreland Road, London, N.W.9.

Reports and Dividends

Qualcast, Limited—Interim dividend of 10 per cent.

Heenan & Froude, Limited—Interim dividend of 5 per cent.

Crabtree Electrical Industries, Limited—Interim dividend of 5 per cent.

Worthington-Simpson, Limited—Dividend of 10 per cent. on the ordinary shares.

G. D. Peters & Company, Limited—Net profit for 1939, £128,793; final dividend of 15 per cent., making 30 per cent.

Joshua Bigwood & Son, Limited—Dividend on the 6 per cent. preference shares for the half-year to September 30, 1939.

Hadfields, Limited—Net profit for 1939, £264,298; final dividend on the ordinary shares of 15 per cent., making 22½ per cent.

Midland Electric Manufacturing Company, Limited—Profit for 1939, £48,834; dividend of 10 per cent. and a bonus of 10 per cent.

Guest Keen Baldwins Iron & Steel Company, Limited—Dividend of 5 per cent. on the ordinary shares for the year ended December 31 last.

Cammell Laird & Company, Limited—Net profit for 1939, after charging £300,000 for taxation, £225,394; brought in, £60,328; to general reserve, £100,000; final dividend on the ordinary stock of 6 per cent, making 10 per cent. for the year; carried forward, £65,023. Meeting, April 2.

Boulton & Paul, Limited—Net profit, together with dividends received from subsidiaries and balance of £11,121 brought in, £109,318; income tax, N.D.C. and E.P.T., £60,000; preference dividends, £8,775; to general reserve, £10,000; dividend of 5 per cent. on the ordinary shares, £8,125; carried forward, £23,418.

National Gas & Oil Engine Company, Limited—Profit for 1939, after provision for depreciation and including income from investments, £32,786; provision for taxes and a portion of A.R.P. expenditure written-off, £4,000; brought in, £19,717; dividend on the preference shares for the half-year to June 30, 1939, £6,000; dividend on the preference shares for the second half of 1939, and on the ordinary shares for the year at the rate of 2½ per cent., £21,000; carried forward, £21,503.

Forthcoming Events

MARCH 15.

Institution of Mechanical Engineers:—"Fifty Years of Marine Engineering," Thomas Lowe Gray Lecture, by Prof. A. L. Mellanby, at the Institution, Storey's Gate, London, S.W.1, at 6 p.m.

Manchester Association of Engineers:—Annual general meeting, and "Demolition of the 'Mauretania.'" Paper by M. Wilkinson, at the Engineers' Club, Manchester, at 7 p.m.

Refractories Association of Great Britain:—Annual general meeting, at Royal Victoria Hotel, Sheffield, at 4 p.m.

MARCH 18.

Institution of Mechanical Engineers (Western Branch):—"Works Management in the Small Factory." Paper by T. G. Rose, at Merchant Venturers' Technical College, Bristol, at 7 p.m.

Sheffield Society of Engineers and Metallurgists:—"Recent Heavy Hydraulic Forging and Bending Presses." Paper by J. A. Anderson, at Grand Hotel, Sheffield, at 7.30 p.m.

MARCH 19.

South Wales Institute of Engineers:—"Electricity as Applied to Metallurgy," William Menelaus Memorial Lecture, by Dr. A. P. M. Fleming, at the Institute, Park Place, Cardiff, at 3.15 p.m.

MARCH 20.

Manchester Metallurgical Society:—"Gases in Metals." Paper by Prof. F. C. Thompson, and annual general meeting, at Engineers' Club, Manchester, at 6.30 p.m.

Institute of British Foundrymen

MARCH 16.

Wales and Monmouth Branch:—Annual general meeting, and "Moulding Problems in a Steelfoundry," Paper by E. J. Kelly, at University College, Newport Road, Cardiff, at 3 p.m.

MARCH 20.

London Branch:—"Merchandising of Castings." Paper by R. B. Templeton, at Charing Cross Hotel, London, W.C.2, at 7 p.m.

MARCH 21.

Middlesbrough and District Branch:—"The Ford Foundry and the Production of Castings for the Ford Car." Paper by H. A. Fox, at Cleveland Technical Institute, Corporation Road, Middlesbrough, at 7 p.m.

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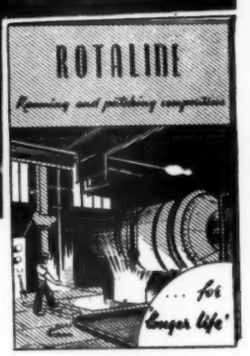

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Raw Material Markets

Although steel-making plant will in most cases be idle during the normal Easter holiday, this does not imply that the industry is discontinuing or relaxing in any way its efforts to meet the insistent demands of the consuming trades. On the contrary, the break will afford the opportunity to repair plant where necessary, while employees will doubtless benefit from the rest. The Easter policy of the industry was, in fact, advised by the Government.

Pig-Iron

MIDDLESBROUGH—The position of the foundry iron trade in the Cleveland district is especially interesting at the present time; normally, in addition to meeting the requirements of local consumers, the trade is able to despatch large tonnages to Scotland and other areas, but now the needs of North-East foundrymen are having to be met from the Midlands. There is no output of Cleveland iron, and what stocks were on hand have been disposed of. While there are certain obvious disadvantages in the existing conditions, it is appreciated that the need for the production of other descriptions of iron now being made is of vital importance. Cleveland foundries are getting satisfactory deliveries from the Midlands, although it is difficult to procure more than current needs. However, this is a precautionary measure which is being applied with success to most departments of the iron and steel industry. Heavy foundries generally are operating on a good scale, but there is still little improvement to report regarding operations at the light foundries.

The current production of East Coast hematite is moving away freely, stocks which existed last summer having been passed into consumption in most instances. Makers' order-books are as full as is practicable under existing conditions, the bulk of the present trade being of a hand-to-mouth character. Demand on home account precludes the transaction of more than a meagre amount of export business.

LANCASHIRE—It is difficult to sum up in a few words the state of trade among light-castings and jobbing foundries in this area, as the position is so variable, but it would seem that, on the whole, business among these concerns is not particularly brisk, as is evidenced by the call for fresh supplies of pig-iron. On the other hand, heavy electrical concerns and machine-tool makers are almost universally busy and large tonnages of iron are passing to these concerns. Most of these works are fully booked up, and their commitments extend over many months. Deliveries of pig-iron are, however, quite sufficient to meet all requirements. The demand for West Coast hematite is steady; although many buyers would doubtless like to cover their forward needs, this is difficult, makers being committed as far ahead as is practicable.

MIDLANDS—The bulk of the demand for iron in this area continues to emanate from the heavy engineering section, most of the lighter concerns being still short of work, owing to the dull conditions existing in the building trade and the falling away of the export market. It is obvious that, unless the Government is able to place contracts with the light-castings industry, intermittent working will continue, as building operations appear to be curtailed for the duration of the war, while the expansion of the export trade can at the best be only slow. Thus, the call for high-phosphorus iron is within narrow compass. Most other pig-iron users, however, are working to capacity, and the call for supplies of low-phosphorus iron and hematite is fully maintained. Government contracts mostly account for this position. Supplies of iron are by no means plentiful, but by a policy of careful distribution little hindrance is caused to consumers. Users are not always receiving the particular grade to which they have become accustomed, but a suitable alternative is generally forthcoming to satisfy requirements.

SCOTLAND—Concerted action is being taken by light-castings makers in the hope of improving their lot; this section has been severely hit by the war on account of the loss of certain outlets, and as yet there has been little or no compensation in the form of Government orders to alleviate the situation. Heavy foundries, on the other hand, are pressing for deliveries, and there has lately been an expansion in the call for supplies. Deliveries are coming through quite well, but the pressure recently has been pronounced. Imports of foundry and basic irons continue to arrive regularly.

Coke

Deliveries of foundry coke from the ovens are being made satisfactorily; although most of the larger users are in possession of adequate supplies, there is a movement towards the accumulation of fresh stocks in order to replenish the reserves drawn upon when tonnages were difficult to obtain earlier in the year owing to transport being abnormal. The ovens are in a position to meet all demands, as has been the case for many months past. For delivery to Birmingham and Black Country stations, the current price of Durham best coke remains at 53s. per ton; this quotation is officially controlled, and thus may be altered by the authorities at any time. All forward contracts consequently carry a rise-and-fall clause.

Steel

Shipments of steel semis to the United Kingdom continue to be quite satisfactory, and are thus improving the situation in the industry, all sections of which are uniformly active. Most works have specifications on their books involving deliveries over a long period ahead, but business on hand is being tackled in such a way as to promise that all consumers classed as "priority" concerns may expect to be supplied with adequate tonnages to enable them to maintain satisfactory outputs. Only scant attention can, of course, be paid to ordinary domestic users in the circumstances, while exports continue to be restricted.

Scrap

Favourable comment has been made generally with regard to the new scrap iron and steel prices referred to at length in our last issue. It is hoped that additional supplies will now be forthcoming, thus making imports less necessary and reducing costs of production in that way. Any such economies are, of course, the more important in time of war, and must be pursued with increasing vigour. If holders of scrap exist, they are now expected to dispose of their supplies, for which the demand is insistent. The collection campaign has undoubtedly received a stimulus by the new price schedule, and should soon be able to report additional success in its endeavours to bring out old metal.

Metals

The plans of the Allies to ensure adequate supplies of copper for the duration of the war appear to be working well, despite the apparent shortage of the metal for projects other than those connected with the war effort. Deliveries to the United Kingdom are coming through regularly, enabling the output of munitions to be maintained at a very high level. Even if shipping delays should occur more frequently in the future, the production of munitions will not be restricted through lack of copper. France, too, has covered her requirements over a long period ahead. Japan is understood recently to have placed an order for 1,000 tons of American copper at 11.60 cents, f.a.s., for shipment during this and next month.

An interesting announcement affecting the tin market was contained in an Order in Council, effective from March 25, which provides that the sale proceeds of tin from the United Kingdom and the producing colonies, when exported to certain countries outside the Empire, must be paid for in one of three ways:—(*a*) By sterling bill drawn under a credit opened by the buyers with a bank in the United Kingdom, with an undertaking by the buyer to obtain the necessary sterling by a sale to the bank of either belgas, guilders, Netherland East Indian guilders, Swiss francs, or United States dollars; (*b*) In sterling paid in the United Kingdom and obtained by the buyer by a sale of one of the above currencies to a bank in the United Kingdom after September 3, 1939; (*c*) in one of these currencies paid to a bank in the United Kingdom or to its agent abroad for the account of such bank. Similar arrangements have been made in the Colonies and allied to the existing export licensing system. Full details are given in the Notice to Exporters and in Form CD1 which now has to be used.

The tin market in London has had a firmer tendency since the publication of the new foreign exchange regulations, which has resulted in higher prices in the United States.

Metal market prices for tin were as follow:—

Cash—Thursday, £255 5s. to £255 10s.; Friday, £256 5s. to £256 15s.; Monday, £258 to £258 10s.; Tuesday, £256 15s. to £257; Wednesday, £254 15s. to £255.

Three Months—Thursday, £254 15s. to £255; Friday, £255 10s. to £255 15s.; Monday, £257 to £257 5s.; Tuesday £255 15s. to £256; Wednesday, £253 15s. to £254 5s.

The demand for high-grade and g.o.b. spelter is fully maintained, and supplies continue to be directed mainly into channels concerned with Government contracts. Supplies of lead, on the other hand, seem to be more than sufficient to meet all demands, but consumption in the industries connected with war materials is nevertheless substantial. The production of spelter in America in February was 54,500 tons, compared with 57,200 in January. Deliveries were 53,000, compared with 57,600, while stocks at the end of February were 67,100, compared with 65,600 at the end of January.

Stimulating Export Trade

NEW COUNCIL'S AIMS

A statement setting out the aims and plan of work of the Export Council, which was constituted recently by the President of the Board of Trade to help in achieving the big expansion of export trade made necessary by the exigencies of war, was issued last Thursday as a White Paper. Sir Andrew Duncan is chairman of the Export Council. Mr. F. D'Arcy Cooper (chairman of Lever Bros. and Unilever, Limited), Sir Clive Baillieu (chairman of the National Smelting Company, Limited), Lord Hyndley (Commercial Adviser to the Mines Department), and Sir Cecil Weir (chairman of the Export Trade Committee of the Association of British Chambers of Commerce) are acting as the Council's Executive Committee.

The statement says that the Export Council aims at promoting the greatest volume of export trade which can be achieved under war conditions. Their duty is to ensure that every agency concerned, whether Government Department, manufacturer, or exporter, makes every effort to attain this objective, and they will recommend any measures which they find necessary or desirable. The maintenance of export trade is so vital a factor in the war effort of the Allied Powers that no measure calculated to contribute to the end in view should be excluded from consideration. Nevertheless, there are powerful reasons why the strongest preference should be given to measures which involve least interference with the existing channels of trade or with established practices or principles. The Council endorse the view of the executive members that, the more war export trade is built on the normal structure of trade, the sounder and healthier will be the state of the trading organism at the end of the war, when more critical and testing conditions are likely to be encountered.

The Council emphasise that, for reasons of limitation of supplies, if for no other, the export trade necessary to win the war can only be achieved by some diversion from the home market. Referring to the formation of war export groups by industries, the Council say it is regarded as vital that there should be an export committee or group in individual industries. The executive members of the Council have already opened discussions with a large number of industries with a view to action on these lines.